Report of the Committee

on

Wear & Tear, O&M and Plant Lifespan Implications

due to flexible operation

and

Analysis of 2-shift Operational Data

Contents

1. Background

In a meeting held under the Chairmanship of **Secretary (Power)** on **27.05.2025,** NTPC expressed serious concerns over two-shift operations and 40% load flexing, citing their adverse impact on the unit health. NTPC also expressed that operating units below 55% load is technically not feasible, particularly due to issues such as poor coal quality. Further, it was stated that NTPC is already experiencing high boiler tube leakages, frequent flame failures, and a significant increase in generator and turbine failures over the past three years. It was mentioned by NTPC that repeated ramp-ups and ramp-downs are accelerating wear and reducing the lifespan of thermal units. NTPC added that consequently they are not in a position to support two-shift operations.

Secretary (Power) observed that CEA and GRID-INDIA, in consultation with generators, should first thoroughly examine the potential damage to the country's thermal plant fleet including wear and tear, O&M, and plant lifespans before considering implementation of two-shift operations.

Consequently, a committee was constituted in CEA with the following composition:

1. Shri B.C. Mallick, Principal Chief Engineer-II - *Chairman*
2. Sh. Surata Ram, CE(TPRM), CEA/Sh. Pravir Kumar - *Member Convener*
3. Sh. SK Pandey , CGM , DVC - *Member*
4. Sh. Partha Nag , CGM , NTPC - *Member*
5. Sh. R. Sahoo, GM, WBPDCL - *Member*
6. Sh. Manoj Kumar Agrawal, Executive Director, NRLDC, GRID-INDIA - *Member*
7. Sh. S Bhattacharya, GM, BHEL – *Member*
8. Shri Shubhranshu Patnaik, Partner, Deloitte India – *Member*

Following are the representative as Special Invitees: -

1. Sh. Anjan Kumar Sinha, Technical Director, Intertek
2. Sh. Ripu Bhanjan Singh, USISPF
3. Sh. Rohit Yadav, Deputy Director, CEA
4. Sh. Vikalp Saini, Assistant Director, CEA

Other Special Invitee for the Committee meeting on 18.05.2026 and 13.08.2026

5. Sh. Sumanta Basu, Head of Industrial Innovation and Operations, Visionaize Technologies Private Limited and former Head of Department, **L&T-MHI Power Boilers Pvt Ltd**

The **mandate of the Committee** was to examine the **potential damage to thermal power plants** on account of flexible operation and also to examine the impact of two-shift operations in generating units. The terms of reference (TOR) of the committee:

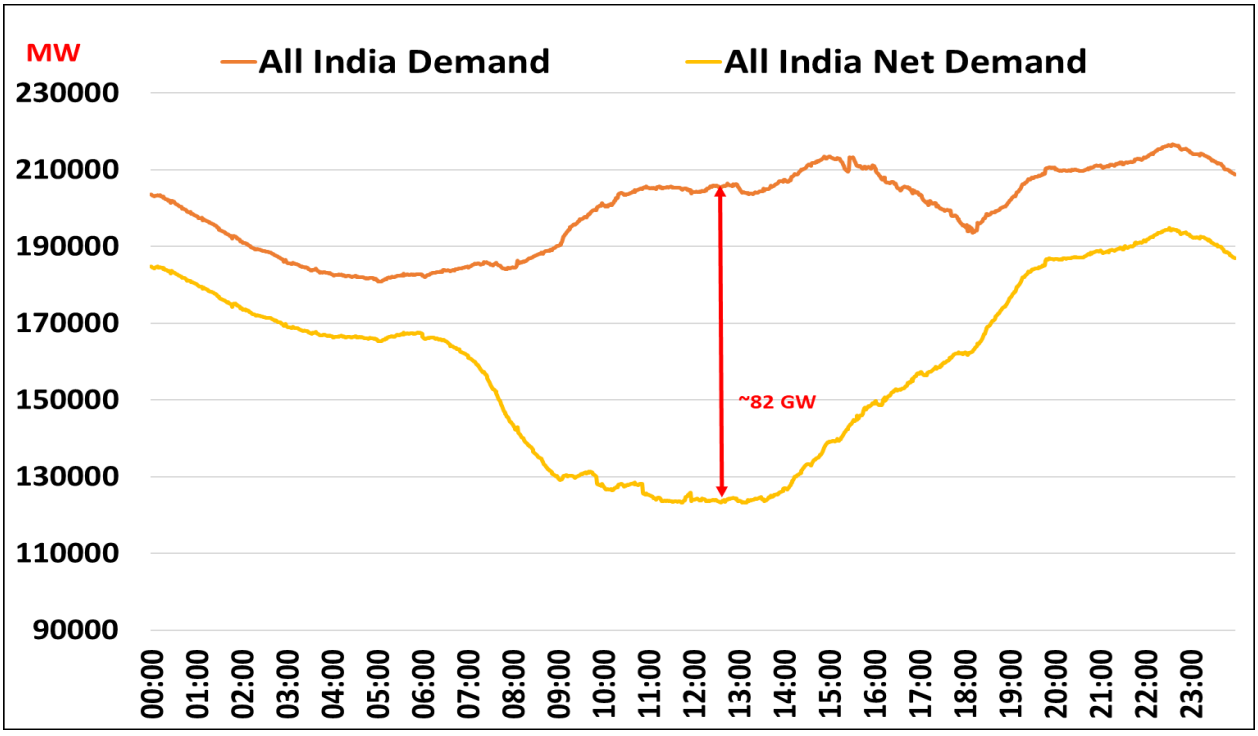
i. Assessment of increase in wear & tear, increase in O&M and impact on plant's life.
ii. Analysis of operation data of generating units where damages has been reported due to flexible operation.
iii. Conduct feasibility study for two-shift operations and examine impact on units' life.

Three meetings of the committee were held with the participation of representatives from CEA, NTPC, DVC, BHEL, Grid India, Intertek, USISPF and other special invitees on 02.07.2025, 19.08.2025,15.10.2025, 18.05.2026 and 13.08.2026

2. Status of Indian Grid in terms of Grid Balancing

2.1. Present Grid Scenarios:

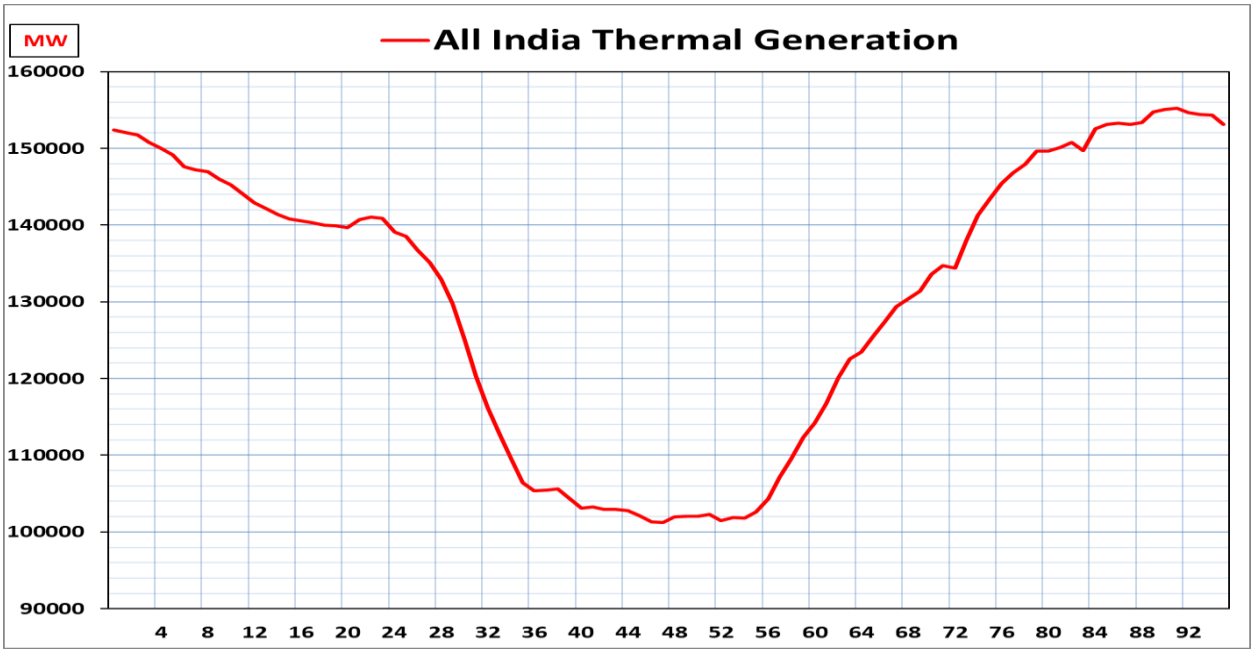
The increasing penetration of solar generation is leading to a pronounced "duck curve" in the All-India demand profile, with very low net demand during solar hours and sharp ramps in the evening. On certain days, the difference between maximum demand and minimum net demand reached about 82 GW, significantly increasing the requirement for ramping and turndown capability. During midday solar hours, thermal generation is often pushed close to its technical minimum, leaving very limited downward margin to absorb additional solar generation. This makes flexible operation of thermal units through deeper turndown, faster ramping, and frequent cycling essential for maintaining grid security and enabling further RE integration. Plot of all India net demand and gross demand is given below



The all-India diurnal demand variation is of the order of 75 GW, with national ramping requirements typically in the range of 250–300 MW per minute, rising to 500 MW per minute on certain days. Achieving India's target of 500 GW of renewable energy capacity and 50% non-fossil energy by 2030 is contingent upon significantly enhancing grid flexibility through a combination of flexible thermal operation (40% MTL), two-shift operation, battery energy storage systems (BESS), and pumped storage projects (PSPs).

2.2. Present level of flexing provided by ISGS thermal and aggregate All India thermal capacity

At present, Inter-State Generating Stations (ISGS) thermal stations as well as the aggregate All-India thermal fleet are already providing substantial operational flexibility. Analysis of All-India thermal generation indicates that daily flexing (maximum–minimum generation) has progressively increased over time and, on several days, now reaches up to approximately 60 GW, reflecting system-wide ramping to accommodate variability in net demand. ISGS thermal units routinely back down close to 55% of their declared capacity during solar hours and ramp up sharply during evening peak hours. A similar flexing behaviour is also observed at the All-India thermal generation level, demonstrating that flexibility is being provided not only by ISGS units but across the broader thermal fleet with some constraints. The All-India thermal generation flexing trend is illustrated in the figure below. A MW versus 15-minute time-block plot for all India thermal generation is given below:



2.3. Over-frequency events and role of ancillary services

The analysis for May–July 2025 shows that the system frequency exceeded 50.05 Hz for more than 20% of the time on a large number of days, indicating recurring periods of surplus generation or limited downward flexibility. In May 2025, several days recorded particularly high occurrences, with frequency remaining above 50.05 Hz for 30–37% of the day on multiple days, reflecting strong over-frequency tendencies during high RE generation periods. From May 2025 onwards, the provisions of Emergency Ancillary Services were in force, which helped in containing over-frequency conditions through corrective despatch actions. Despite this intervention, in June and July 2025, the extent and intensity of such occurrences appear relatively moderate, suggesting the positive impact of ancillary service deployment, though exceedances beyond the 20% threshold continue to be observed. Overall, the analysis shows that persistent over-frequency events underline the continuing need for enhanced downward flexibility, deeper turndown capability of thermal units, and complementary balancing resources to manage increasing RE penetration effectively. Month-wise details of frequency exceedances during May 2025 to July 2025 are given below:

Frequency > 50.05Hz (for more than 20% of time) : May-25

Su	Mo	Tu	We	Th	Fr	Sa
				1 31%	2 37%	3
4 27%	5 29%	6 22%	7	8	9	10 27%
11	12	13	14	15	16	17
18 33%	19	20	21 27%	22 37%	23 24%	24 27%
25 30%	26 25%	27 22%	28 27%	29 36%	30 29%	31 32%

Highlighted days when frequency remained above the band for 20% of the time of the day.
(The percentage of time frequency remained above the band is indicated against the date)

Frequency > 50.05Hz (for more than 20% of time) : Jun-25

Su	Mo	Tu	We	Th	Fr	Sa
1 25%	2 24%	3	4 29%	5	6	7
8	9 26%	10 25%	11	12	13 20%	14
15 20%	16 23%	17 29%	18 30%	19	20 25%	21
22 22%	23	24 33%	25	26	27	28 21%
29 35%	30 25%					

Highlighted days when frequency remained above the band for 20% of the time of the day.
(The percentage of time frequency remained above the band is indicated against the date)

Frequency > 50.05Hz (for more than 20% of time) : Jul-25

Su	Mo	Tu	We	Th	Fr	Sa
		1 20%	2	3	4 26%	5 29%
6 25%	7	8	9 27%	10 23%	11	12 23%
13 25%	14 26%	15 20%	16 28%	17 20%	18 25%	19
20	21	22 24%	23 20%	24	25	26 21%
27 22%	28 22%	29 23%	30 21%	31 22%		

Highlighted days when frequency remained above the band for 20% of the time of the day.
(The percentage of time frequency remained above the band is indicated against the date)

2.4. Constraints in achieving deeper thermal flexibility

GRID-India highlighted the prevailing grid security challenges during May 2025, wherein system frequency remained above the Indian Electricity Grid Code (IEGC) operating band for nearly 20% of the time, with sustained high-frequency conditions during solar hours for almost four hours within the 06:00-18:00 hrs window. On 25th May 2025, despite backing down the national thermal fleet to approximately 58% and curtailing nearly 10 GW of solar generation through Tertiary Reserve Ancillary Services (TRAS) emergency down dispatch, system frequency still rose to 50.48 Hz, posing a serious concern for safe and secure grid operation. The extent of RE curtailment month wise as intimated by Grid India is given below:

Month	Maximum RE Down		Duration of RE Down	
	MW	Date of Max RE Down (MW)	Hrs	Date of Max RE Down (Hrs)
May	11383	31-05-2025	6.75	25-05-2025
June	13574	01-06-2025	7.25	01-06-2025
July	4623	29-07-2025	4.25	01-07-2025
August	11263	10-08-2025	8.00	24-08-2025
September	13637	28-09-2025	7.25	28-09-2025
October	23432	12-10-2025	8.25	02-10-2025
November	16413	09-11-2025	6.25	02-11-2025

Due to the inability of several thermal stations-particularly at the intra-State level-to operate at 55% MTL, maximum renewable energy curtailment more than 23 GW, as indicated in the above Table, had to be undertaken during high solar generation periods, underscoring the urgent need for deeper thermal flexibility. It was also pointed out that several generating units are already operating below 55% MTL, including Shree Cement (≈30% of DC), Rajpura (≈50%), Talwandi Sabo (≈50%), Adani Raigarh (≈45%), and Mahan (≈45%). Shree Cement's merchant plant, Beawar, Rajasthan in the Northern Region was specifically cited, which operates at around 45 MW (30%) during solar hours and ramps up to full capacity (≈150 MW) during non-solar hours, demonstrating the technical feasibility of low-load operation.

2.5. Exceptional days when reserve shut down of multiple thermal units are required

Exceptional days such as extended weekends, holidays, and weather-dominant days often lead to abnormally low net demand conditions, driven by reduced industrial and commercial load coupled with high renewable generation. During such periods, despite maximising turndown and ramping flexibility, the system may face insufficient downward margin, necessitating reserve shutdown (RSD) of multiple thermal units to contain over-frequency and maintain grid security. However, following the extended holidays, it becomes equally critical to ensure that an adequate number of thermal units are restored and kept on bar to meet the sharp rebound in demand during evening peak hours.

In this context, it was observed that due to the extended weekend around 15.08.2025 holiday, thermal capacity of about 16 GW remained under RSD. Accordingly, requests were issued to all States and Central Generating Companies in anticipation of rising demand, and Central Gencos were committed through the day-ahead SCUC process. Nevertheless, delays in revival arising from operational challenges such as crew constraints and unit-specific issues resulted in inadequate availability during peak hours, leading to system frequency dropping to as low as 49.46 Hz during the evening, highlighting the operational risks associated with delayed unit restoration after prolonged low-demand periods.

3. International Scenario on flexibility/ Minimum Technical Load (MTL)

The minimum technical load (MTL) of coal-fired power plants operating in various countries is given below:

Country	Typical MTL (Baseline Fleet)	Achievable MTL with Flexibility Measures / Retrofits	Remarks on Flexible Operation
China	50–60% of rated capacity	~30% (some units 20–30%)	Large baseload-oriented fleet; national retrofit programs to support high RE integration
Denmark	~30%	~20–25%	Smaller but highly flexible coal fleet; advanced combustion control and operating practices
United States	40–50%	~30–40% (limited cases lower)	Majority of units designed for baseload operation; limited deep-flexibility retrofits
Japan	~30%	~15–20% (Flex-USC designs)	Modern USC/Flex-USC units with strong focus on part-load efficiency and cycling capability
Germany	~40%	<20% (specific units ~12–15%)	Extensive retrofits driven by very high wind and solar penetration

4. Regulatory Provisions relating to Minimum Technical Load (MTL) and 2-shift operation

CEA had also envisaged the requirement of two-shift operation much earlier and incorporated relevant provisions in:

- Technical Specifications of Sub-critical Thermal Power Projects (September 2008), and
- Standard Technical Features for BTG Systems for Supercritical 660/800 MW Units (July 2013).

Central Electricity Authority (CEA) initiated countrywide 40% low load operation pilot study/tests in association with international partners (IGEF, DEA, JCOAL) and OEMs (BHEL, GE, SIEMENS) since 2018 which demonstrated the 40% low load operation capability of coal-based generators. Considering high ash content in Indian coal, and after 5 years successful multiple pilot study/test, CEA notified flexible operation regulation in 2023 regarding 40% minimum technical load (MTL) of coal-fired power plants to be achieved phase-wise by 2030.

CEA also published following two reports wherein the requirement of 40% load operation and 2-shift operation was envisaged for integration of renewable generation into grid:

- "**Flexible operation of thermal power plant for integration of renewable generation**"- a roadmap for flexible operation of thermal, gas and hydro power stations, published in 2019.

- "**Flexibilisation of coal-based power plants"-** a roadmap for achieving 40% Technical Minimum Load, published in 2023.

As per the above reports, the utilities shall conduct detailed study/tests and cost benefit analysis for finding the most optimal solutions to improve the flexibility of plants as the measures required are plant specific and shall depend on the level of flexibilisation. This may be done in consultation with OEM/main plant (BTG) manufacturer /BTG designer.

5. CEA's views on Minimum Technical Load (MTL) and 2-shift operation

Enabling two-shift operation and operation at lower technical minimum loads below 55% is crucial to avoid renewable curtailment and ensure secure grid management. The Committee during its deliberations in the meeting was of the view that running a unit at 40% load is **operationally less damaging** compared to repeated **Reserve Shut Down (RSD)** cycles. Hence, analyzing wear and tear impacts of two-shift operation and establishing a technical basis for compensation and operational planning is essential.

Therefore, conducting a pilot study on two-shift operation is indispensable for assessing wear and tear impacts, determining appropriate compensation mechanisms, and addressing operational concerns in a structured manner. The initiation of the pilot at the earliest is critical to enable implementation of two-shift operations on selected units within the next two years, in line with evolving grid requirements.

6. CERC's direction for 2-shift operation

GRID-India apprised the Committee that CERC, vide order dated 29.03.2025 in Suo Motu Petition No. 2/SM/2025, directed to conduct pilot projects for two-shift operation of thermal generating stations, and tasked NLDC with identification of suitable candidate units (covered in Section 62 of Electricity Act 2023, rail-fed, preferably >500 MW). Accordingly, NLDC identified candidate units and communicated the same to NTPC vide letter dated 22.05.2025, requesting confirmation of unit readiness and submission of start-up cost data for hot and warm starts.

However, NTPC, vide its letter dated 13.06.2025, sought exemption from participation in the proposed pilot study, citing technical and operational constraints, reliability concerns, and the comparatively higher efficiency and environmental performance of its units. GRID-India highlighted that as per the CERC order, the pilot project for two-shift operation is mandatory, and that incentives during the pilot period have also been specified by CERC. The pilot study is essential for a realistic assessment of

wear and tear, increased O&M expenditure, and operational impacts, which would enable formulation of a robust and evidence-based compensation mechanism.

7. Analysis of operation data of generating units and Assessment of damages

7.1. Receipt of Operational/ technical data of NTPC's power plants with NTPC's views

NTPC generating units are presently operating at 55% Minimum Technical Load (MTL); however, NTPC has not operated its units below this level. NTPC submitted that it is witnessing an increased incidence of Boiler Tube Leakages (BTL), which, according to NTPC, are attributable to thermal fatigue arising from low-load and flexible operating conditions. NTPC emphasized that, from the perspective of grid balancing and minimization of equipment damage, multiple ramp-up and ramp-down cycles per unit per day should be avoided, as such operating patterns significantly aggravate thermal stresses and fatigue damage.

NTPC also highlighted that total 692 Boiler Tube Leakages (BTL) were reported fleetwide from FY 2021–22 to September 2025, averaging 6.68 BTL per unit. 10 instances of flame failure and 11 of 15 BTL events at Farakka were attributed to fatigue failure, overheating, and weld joint failure.

The committee members requested NTPC during the 1st meeting held on 02.07.2025 to submit operational/ technical data in a prescribed format of any unit which was operating flexibly up to 55% MTL leading to damage.

After some reminders and considerable persuasion, NTPC submitted operational/ technical data on 07.10.2025 to the Committee for analysis (after three months). Data pertaining to Farakka Unit–2 (210 MW) of age 39 years old and Jhajjar Unit–3 (210 MW) of age 13 years, covering outage categorization, ramping behavior, and operational events during flexible operation. NTPC submitted that the data reflects increased mechanical and thermal stresses experienced by plant components due to flexible operation at 55% MTL.

7.2. OEM's perspective on damages

As per OEM (BHEL), although equipment damage is being observed under flexible operation regimes, such damage cannot be attributed solely to flexible operation. This is because, the observed deterioration comprises three distinct components:

(i) Damage arising from the historical operating profile of the unit, including past operating regimes, ageing, past & prevailing O&M practices;
(ii) Damages resulting due to generating station catering to Grid load requirements under AGC & SECD, etc. and
(iii) Additional damage attributable to the current flexible operation regime as the sets have not been customized for flexible operation and hence are operating with higher parametric variations/ deviations resulting in accelerated stress & damage to the equipment.

It is also highlighted that in many cases there may be a possibility that, critical equipment and components were already operating close to their failure threshold prior to the commencement of flexible operation. With the introduction of flexible operation—particularly when carried out using

existing conventional control systems without advanced flexibilisation solutions—the rate of life consumption increases, resulting in earlier manifestation of failures. Accordingly, pre-existing damage and accelerated degradation must be duly accounted for, and failures should not be attributed exclusively to flexible operation.

It was further stated that while flexible operation with current state of equipment inherently results in higher life consumption compared to base-load operation, such impacts can be effectively controlled and mitigated if thermal generating units are suitably upgraded and made capable for flexible operation through the implementation of advanced control and retrofit solutions. As per current design backing down/low load operation i.e. up to55% MTL is considered for twice in a day and up to 40% MTL is considered for once in a day without degradation of machine design life of 25 years. The relatively faster deterioration presently being reported was attributed to the fact that flexibilisation is being undertaken without deployment of comprehensive flexibilisation solution packages.

The OEM (BHEL) also cautioned that almost the entire fleet of generating units are currently operating in flexible mode without implementation of requisite technical solutions, which is likely to result in premature equipment failures and reduced plant life. It was emphasized that merely achieving compliance with CEA's minimum technical load regulations is not sufficient unless accompanied by corresponding technical measures to address the broader implications of flexible operation.

BHEL also informed that damages cited by utilities especially NTPC are not entirely attributable to flexible operation as frequent and rapid load changes are happening in the grid for load balancing. These frequent and rapid load changes should not be accounted on flexible operation head and instead are being carried out as part of grid stabilising mechanism.

Basically, Flexible operation is load cycling corresponding to solar hours which mandates for one ramp down in the morning, stable low load (say 55%) operation for around 4-5 hours and then one ramp up in the evening. However, in reality, it is observed that frequent load cycling of varied orders of load change is are happening throughout the day as per grid mechanisms of AGC, SECD etc. which are having significant damage potential. The situation becomes more detrimental with variations & deviations actually observed in the operating parameters during such cycling. It is further understood by BHEL that utilities are suitably compensated for load changes followed under these mechanisms. Therefore, even though load cycling owing to grid mechanisms of AGC, SECD etc. is more detrimental for the thermal sets but because of the rewards of compensation being actually realized, utilities are doing it without considering their damage potential. Presently the same are being accounted by the utilities as the damages encountered during flexible operation

The OEM (BHEL) further observed that new tenders and technical specifications of these tenders are largely focused only on meeting CEA's regulatory requirements, without incorporating provisions to address the full spectrum of issues associated with flexible operation. In this context, BHEL recommended that solutions required for enabling safe and sustainable flexible operation should be explicitly incorporated into standard technical specifications and tender documents, both for retrofitting of existing units and for new thermal power projects.

The OEM (BHEL) expressed that the damages and stresses associated with flexible operation can be significantly mitigated through appropriate retrofitting and control modifications to enable stable 40% MTL operation and ramp rates as prescribed in CEA regulations.

7.3. Analysis of Data of NTPC units and Assessment of Damages

CEA and Intertek jointly analyzed operational/ technical data of Farakka Unit–2 (210 MW) and Jhajjar Unit–3 (210 MW), as received from NTPC.

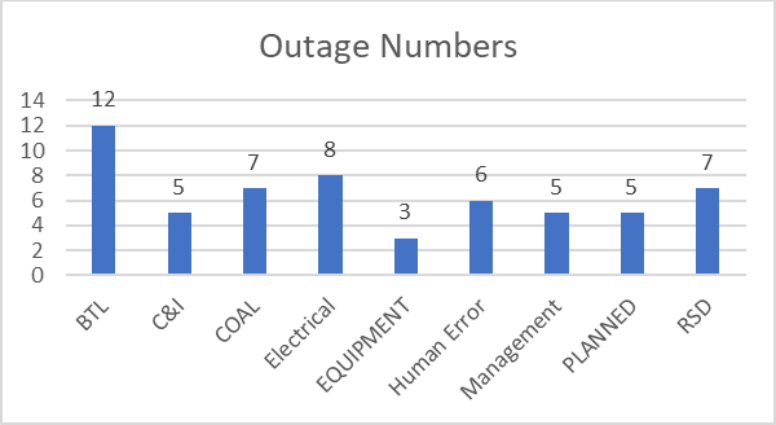
7.3.1. Farakka Unit-2, NTPC:

Farakka unit-2 of capacity 210 MW is about 39 years old which has already completed its useful life. The preliminary analysis of operational data shows that generation losses at Farakka Thermal Power Station over the last five years were attributable to a total of 58 outage events, comprising 12 Boiler Tube Leakages (BTL), 6 shutdowns due to human error, 5 Control & Instrumentation (C&I) related issues, 5 planned outages, and the remaining outages arising from electrical, mechanical, and other operational causes. The analysis further indicated that the observed ramp rates at Farakka TPS remained conservative, generally within 0.5% per minute across most operating blocks.

Categorization of outage events based on cold start, warm start and hot start:

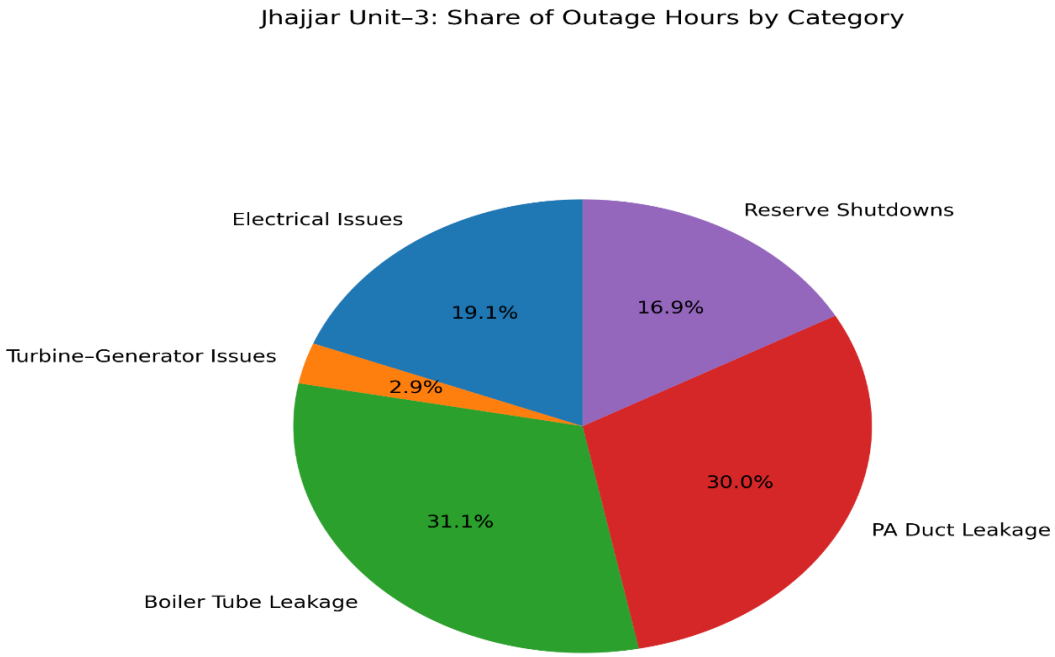
Cold	Warm	Hot
21	14	23

Types of outage events and their occurrences:

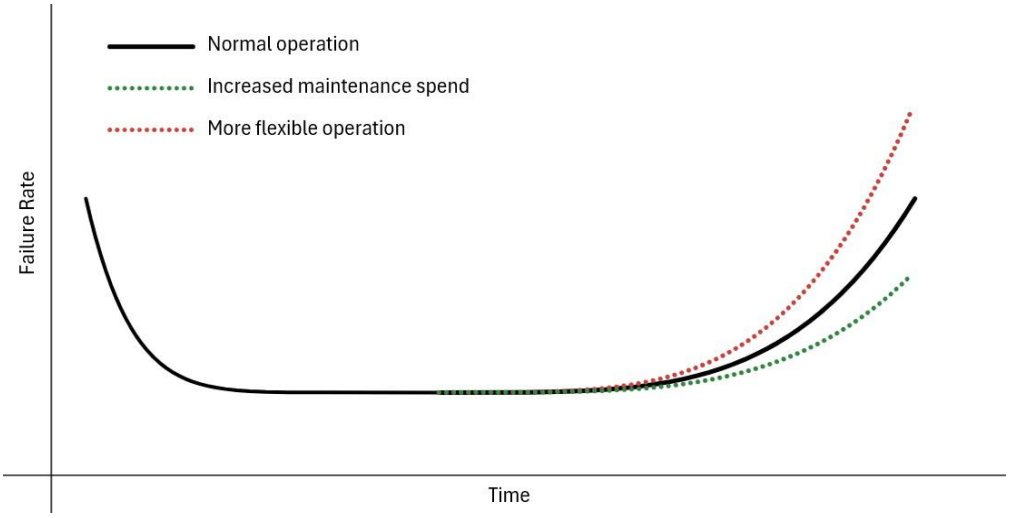


7.3.2. Jhajjar Unit-3, NTPC:

Jhajjar Unit–3 (210 MW) is about 13 years old. Analysis of data for the last one year indicated that generation losses were primarily on account of outages due to electrical issues (32 hours), turbine–generator related issues (4.9 hours), Boiler Tube Leakages (52.3 hours), PA duct leakage (50.35 hours), and Reserve Shutdowns (28.38 hours). The ramp rates were generally conservative, within 0.5%/min, except for isolated instances.



Standard literature depicts failure rates for a unit over its life by a “bathtub curve” as shown in Figure 1. Units beyond their design life naturally show higher failure rates (as represented by the “bathtub curve”).



(Figure 1: Bath Tub Curve)

7.3.3. **Attribution of Damage:**

NTPC's analysis correlates all failures to flexible operation, overlooking other dominant causes such as:

- **Frequent start-ups and shutdowns,**
- Variations in O&M practices
- **Improper preservation or forced cooling,**
- **Coal quality deviation,** and
- **Human and procedural errors.**

Evidence from global and national studies shows that thermal stress and fatigue primarily accumulate during load ramping, start-up, shutdown, and tripping events — not during steady low-load operation.

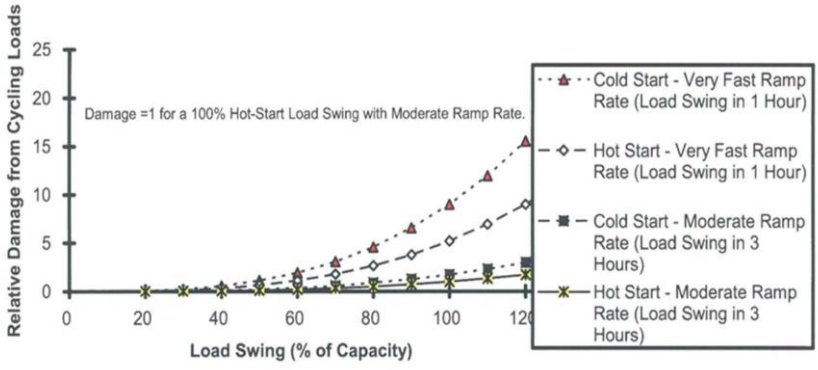
7.3.4. **Influence of Coal Quality:**
Poor coal quality contributes significantly to fatigue and overheating. Even during baseload operation, wide deviations from design coal parameters cause substantial thermal stress unless mitigated by blending.

7.3.5. **Flame Failure and Combustion Imbalance:**
Several flame failures cited by NTPC occurred even at higher loads (>65%), indicating combustion imbalance rather than load-level issues. These events highlight the need for:

- ✓ fuel–air ratio tuning,
- ✓ burner optimization, and
- ✓ systematic fuel blending practices.

7.3.6. **Impact of O&M Practices:**
Increased O&M expenditure and timely maintenance substantially reduce damage rates, often below those experienced under baseload operation.

7.3.7. **Start-up Severity and Operator Practices:**
The **USAID–Intertek "Cost of Cycling" study (NTPC Ramagundam, 2017)** shows that one poorly executed start-up can cause damages equivalent to **16 thermal cycles** in a single component (e.g., reheat desuperheater). Proper operator training and start-up procedures can drastically reduce this damage.



(Figure 2: Assumed Relative Damage under Cycling from Cycling Loads)

7.3.8. **Main causes of damages**:
Both units did **not operate below 55% MTL** during normal conditions. The analysis indicated **no significant damage attributable to low-load operation** at 55% MTL or conservative ramping rates.

Approximately **70% of the observed issues were not due to flexible operation**, but related to **ageing, poor coal quality, or operational disturbances**. It was therefore concluded that while flexibility introduces some additional thermal stress, the existing conservative operations have not shown measurable degradation directly attributable to low-load running.

7.3.9. **Mode-Specific Damage Categorization:**
For accurate assessment, NTPC was requested to provide mode-wise data under:

- steady full-load operation,
- continuous low-load operation,
- ramping operation,
- start-ups (post-tripping and post-outage),
- forced cooling, and
- poor coal quality scenarios.

NTPC was further requested on 15.10.2025 to share operational/technical data of any other units where damages occurred due to flexible operation. However, till the finalization of report (14.01.2026) they have not shared any data to the Committee.

OEM's analysis of NTPC data

With respect to the operational data furnished by NTPC, the OEM noted that the data pertains only to Farakka Unit–2 and Jhajjar Unit–3. Farakka Unit–2 is an aged unit operating beyond its original design life of 25 years, and therefore ageing-related effects on critical components, particularly boiler pressure parts, are expected and need to be considered while analysing the data.

Preliminary examination of the data indicated excursions in boiler outlet and turbine inlet steam parameters beyond recommended limits, both during ramping conditions as well as during steady load operation, suggesting that factors such as operational control, equipment condition, and O&M practices may also be contributing to component stress.

Further, the failure instances shared by NTPC for its fleet across a few stations were observed to exhibit mixed trends, and no uniform or conclusive inference could be drawn from the information provided. The correlation between failures and load ramping, as indicated by NTPC, could not be established based on the statistical analysis made available. Similarly, attribution of the majority of Boiler Tube Leakages (BTLs) exclusively to flexible operation could not be conclusively established on the basis of the data submitted.

8. Need for feasibility study for 2-shift operation

Keeping in mind the present grid scenario and curtailment of large quantity renewable generation the committee decided to carry out the feasibility study for 2-shift operation at smaller size old unit preferably less of equal to 210 MW of age more than 35 years. Accordingly, NTPC, DVC and Mahagenco were requested to offer a unit each to examine viability of two shift operation, potential damage to the unit, retrofits/capex. requirement, tariff impact etc.

Despite four Committee meetings, multiple written requests, and communications from CEA, Grid India, and CERC, NTPC has not nominated any unit for pilot two-shift operation trials. Grid India, in consultation with CERC, had identified ten NTPC units suitable for such trials to establish a scientific compensation methodology, but NTPC has not confirmed any for study. Similarly, DVC and Mahagenco also have not identified/ offered any such unit for feasibility studies.

Details of the two-shift operation pilot study for the 5x210 MW Tuticorin TPS, along with the data analysis, are enclosed in Annexure I.

9. The views of some of Special Invitees

9.1.1. In the meeting of the Committee held on 18.05.2026 held in CEA, Sh. Anjan Kumar Sinha, Technical Director, Intertek gave following further comments:

(a) As highlighted in the discussions, the importance of examining the technical, operational, and maintenance-related implications of flexible operation of thermal power plants in the context of increasing renewable energy integration into the grid was emphasized. It is also emphasized that, with the increasing integration of renewable energy into the grid, flexible operation has become a necessary requirement, and thermal power plants will be required to operate under varying modes and levels of flexibility in accordance with system requirements.

(b) The utilities expressed concerns regarding the damage implications associated with different modes of flexible operation. The Committee reached a common consensus on the significance of assessing the technical, operational, and maintenance-related impacts of flexible operation of thermal power plants. However, in the absence of sufficient actual operational data and comprehensive long-term studies (typically over a period of 5–7 years or more), particularly for supercritical units, no conclusive assessment can presently be made regarding the extent of such damages.

Accordingly, it is suggested that utilities, including NTPC, DVC, MAHAGENCO, and others, undertake a detailed study on “Wear and Tear due to Different Modes of Flexible Operation,” such as low-load operation, load ramping, startups/shutdowns, trips, variations in coal quality, ageing, and related operational conditions, through a reputed and experienced consultant.

(c) The objective of the study should be to segregate and quantify fatigue, creep, corrosion-fatigue, and other degradation/damage cycles over a prolonged period of operation (typically 3–7 years), and attribute such damages to various operational flexibility parameters and cycles, including low-load operation, load ramps, startups/shutdowns, coal quality variations, water-steam chemistry, and other related operating conditions. Such a study is considered essential, particularly for supercritical units.

(d) The proposed study should include a detailed assessment of flexibility-related damages arising from frequent startup and shutdown cycles, load cycling/load ramping, changes in coal quality, equipment runback, and other modes of flexible operation of generating units. The study should comprehensively cover the identification, quantification, and evaluation of degradation mechanisms affecting critical equipment and systems.

(e) All major equipment and systems of the power plant, including boilers, turbines, high-energy piping, balance of plant (BOP), generators, and auxiliaries, should be included in the study, supported by operational data collected over prolonged periods.

(f) In addition, the study should analyse the costs associated with such damages, including equipment life consumption. The extent of damages and associated costs may also be benchmarked against similar global technologies, plant designs, and unit capacities.

9.1.2. In the meeting of the Committee held on 18.05.202, Sh. Sumanto Basu, Head of Industrial Innovation, Visionaize Technologies Private Limited and former Head of Department, **L&T-MHI Power Boilers Pvt Ltd furnished the following** comments and opinion:

(a) NTPC carried out testing only on very old units which are already passed over the 25 years design life. Hence, the failure incidents report and attribution of damages occurred of NTPC on those old units technically shall not be considered sacrosanct with respect to comparatively new and latest installed units. All the failure incidents have been wrongfully attributed to flexible operation as the dominant cause which is incorrect.

(b) NTPC shared only reports on failure incidents. It is advised that NTPC shall mandatorily share the raw data also on those failure incidents to CEA committee for its own analysis and OEM's analysis. OEM has to mandatorily certify the failure incident reports submitted by NTPC or any generating station. Otherwise, the report will be only one-sided findings and decision which may lead to incorrect RCA.

(c) So many testing has been done and results are also known to all stake holders. No further testing is required. Now, the policy needs to be implemented with immediate effect.

(d) Participation of all the generating units to minimum technical load of 40% are to be made mandatory with immediate effect to maintain grid frequency , support renewable energy and avoiding unnecessary TRAS emergency down

(e) Compensation to be paid to the renewable units shall be recovered from the coal fired units which does not participate. Additionally, penalty shall be imposed upon to non-participating coal fired generating units, the quantum of which the committee may finalize.

(f) Since PG test and contract closing of the commissioned units has already completed ,it is believed that all the units designed and commissioned so far by OEM based on post CEA's specification of sub-critical units (Sept 2008) and supercritical units (July 2013) and CEA's flexible operation notification comply with MTL and ramp rate requirement. It is mandatory that OEM and the generating units shall declare commissioned unit's capability in compliance with CEA's specification guidelines and flexible operation notification.

(g) OEMs has to declare all the unit's capabilities with respect to compliance with ramp rate and parameter deviation stipulated in contract specification.

(h) Online real time intelligent monitoring system for thermal stress ,BTL prediction and load/demand forecasting solution shall be implemented mandatorily in all the generating units to facilitate operational decision making and avoiding blindly operating units under constrained condition to support grid with single/ multiple ramps up and ramp down cycles per unit per day. In absence of these online monitoring, the units face multiple BTL, overheating, weld joint failure, fin-cracks, flame failure and large deviation in major operating parameters etc. which can easily be avoidable under monitored operations.

(i) Following shall be implemented in all generating units for better unit control and parameter stabilization at any steady load and ramping load operation in addition to existing traditional control as the boiler heat transfer model changes dynamically under large load variation and fast ramp up/ramp down operating condition during flexible operation:

  (i) Online predictive model-based soft sensor for coal GCV , moisture, VM, ash etc. estimation solution

  (ii) Online combustion optimization, furnace flue gas temperature balancing, metal temperature excursion imitation

  (iii) Coal flow balancing and coal mill through put optimization

  (iv) Intelligent flame analysis and flame failure prediction

  (v) Advanced SH/RH steam temperature optimization

  (vi) FEGT control, monitoring and Intelligent Soot blowing

  (vii) FGMO in service

  (viii) Intelligent demand forecasting

  (ix) AGC in service

(j) Suitable workable CAPEX shall be declared by CEA.

(k) Every industry is applying AI/GenAI and thermal power sector also shall not be an exception in exploring it to facilitate not only the flexible operation but also in day-today O&M activities.

10. Conclusion:

(1) **Operational/ technical data analysis:**

NTPC shared the data for 2 stations. Averaging fleet-wide failures is not a scientifically valid approach, as units differ in age, operating history, maintenance standards, coal quality etc. Units beyond their design life naturally show higher failure rates (as represented by the "bathtub curve"). Based on available data and empirical evidence, it is confirmed that **no significant damage has been observed that can be attributed directly to low-load operation (at 55% MTL and conservative ramp rates).**

The principal sources of accelerated wear and tear remain frequent start-up/shutdown procedures, human & procedural errors, poor combustion management etc.

Therefore, the focus should be on measures implementation for achieving 40% Minimum Technical Load (MTL) in consultation with OEM/main plant (BTG) manufacturer /BTG designer, improving operational discipline, and training of plant operators to manage cycling efficiently, rather than associating damage solely with flexible operation.

(2) **Measures implementation**

Frequent, high-magnitude ramping—not minimum load levels—causes severe wear and tear in coal-based power plants. Furthermore, during consecutive load ramps, the unit lacks the time required to stabilize. This creates additional system disturbances and stresses critical components, while an immediate counter-ramp in the subsequent block compounds the mechanical stress on the system.

The damages and stresses associated with flexible operation (below 55%) can be significantly mitigated through appropriate retrofitting and control modifications. The generating utilities shall conduct detailed study/tests for finding the most optimal solutions to improve the flexibility of plants as the measures required are unit specific and shall depend on the level of flexibilisation. It is also advised to refer CEA's report **"Flexibilisation of coal-based power plants"-** a roadmap for achieving 40% Technical Minimum Load (MTL) published in 2023**.**

(3) **Pilot study for 2-shift operation**

In view of the present grid scenario and curtailment of large quantity renewable generation it is essential to carry out the feasibility study for 2-shift operation at smaller size old units preferably less or equal to 210 MW of age more than 35 years. The pilot study includes examination/tests of unit for viability of two shift operation (to understand technical & operational constraints if any and reliability of 2-shifting), then potential damage (life consumption) to the unit, retrofits/capex. requirement, tariff impact etc.

CEA and BHEL jointly collected data on 2-shift operations at the 5x210 MW Tuticorin TPS in Tamil Nadu. A report detailing 2-shift operation costs, tariff increases, and renewable integration costs is enclosed in Annexure-I.

a) The 2-shift operation of 210 MW size and below units having age 35 years or more is important for integrating 292 GW of solar capacity by 2030, as it provides low-cost integration and increases grid security and stability.

b) The potential capacity of a two-shift operation is about 34 GW, which is capable of providing 24 GW of flexible power/ storage in the grid.

NTPC's observations and the views of the rest of the Committee thereon are enclosed at **Annexure-A** and NTPC's dissent note with regard to the draft Report of the Committee is enclosed at **Annexure-B**.

(4) **Reluctance of NTPC in pilot study for 2-shift operation:**

(a) **CERC's direction for conducting 2-shift operation pilot study**:
On the direction of CERC, NLDC identified candidate units and communicated the same to NTPC vide letter dated 22.05.2025, requesting confirmation of unit readiness for 2-shift operation and submission of start-up cost data for hot and warm starts. However, NTPC, vide its letter dated 13.06.2025, sought exemption from participation in the proposed pilot study, citing technical and operational constraints, reliability concerns, and the comparatively higher efficiency and environmental performance of its units.

(b) **The Committee's request for identification of a unit**:

The committee also requested NTPC to identify an old unit of capacity 210 MW for 2-shift operation pilot study/test. However, they are reluctant and no response has been received since 1st meeting held on 02.07.2025 till finalization of the report. This continued non-availability of pilot units has hindered progress on examination of feasibility, empirical validation of damage mechanisms, delayed formulation of a regulatory compensation framework etc. for two-shift operation.

(c) Potential capacity of 2-shift operation in the country

The two-shift operation of older generating units provides a low-cost alternative for integrating renewables compared to Battery Energy Storage Systems (BESS). The potential from two-shifting—acting as a virtual storage capacity of 27 GW—is about 34.5 GW, which can be developed for just ₹30,200 to ₹37,750 crores, whereas equivalent BESS capacity would cost approximately ₹1,75,500 crores.

(5) **The proposal for 40% flexible operation of coal-based power plants was published by the CEA in 2019 and 2023,** based on successful pilot studies conducted across the country. Thereafter, the CEA's Flexible Operation Regulations were notified in 2023, mandating a 55% load (within one year) and a phased reduction down to 40% by 2030.

The concept of 40% minimum load operation was first initiated by a Task Force Committee in 2017, which was headed by Sh. K.K. Sharma, the then Director (Operations) of NTPC.

On October 27, 2017, the Task Force Committee published a report recommending the following roadmap for implementing flexibilization measures:

A. A minimum load of 50% is to be implemented across all stations, with an assessed implementation timeline of 2 months.

B. The implementation to reach a minimum load of 40% is the next step, with an assessed timeline of 6-12 months.

The report was reviewed and accepted by the Ministry of Power (MoP).

For large scale integration of RE and minimize the adverse impact of low load operations following are the recommendations of the committee.

11. Recommendations (For large scale integration of RE and minimize the adverse impact of low load operation):

(1) As frequent ramping causes more severe wear in coal plants than low loads, plants running on low load should avoid frequent load changes. Instead, share flexible duties fairly among all fitting units to balance operational stress, optimize asset life, and enhance long-term reliability.

a) Avoid consecutive ramp-up and ramp-down of the same units or plants; instead, select a group of units for ramp-up and another group of units for ramp-down. Ramping schedules should be rotated among a pool of units or plants rather than assigned strictly according to the Merit Order. This will alleviate the stress exposure of individual TPPs and share the burden among a larger pool of units to preserve the overall health of the plants.

b) A set of power plants shall ramp down to the Minimum Technical Load (55% or 40%) in the morning when solar generation increases, followed by minimum load operation during solar hours and then load ramp up in the evening when solar generation declines, or sufficient stabilization time shall be provided before change in direction of ramp. The Merit Order Despatch (MOD) may be reviewed, if necessary, to adopt the above recommendations. This will reduce the O&M costs of power plants and extend their operational life.

c) As thermal sets ramp up in diagonal manner, they cannot give a step ramp/ change in load. Therefore, while ramping up/down, a new concept called ramping block should be introduced. In such a block, the target load will be achieved at the end of the block & generation in the block will be about 50% less/ more than scheduled generation. It is recommended to multiply 0.5 with schedule generation of 15-minute block when raping (up/down) to avoid penalty (DSM) due to less generation during ramping up and excess generation during ramping down.

d) Introduce stable-load (stabilization) blocks between ramping blocks to allow the unit to stabilize before the next ramp command which will reduce the O&M costs of power plants and extend their operational life.

e) Instead of using the thermal fleet for fine grid balancing, the same may be done from other sources, such as hydro power plants, gas power plants, pump storage plants, and, BESS.

f) Utility shall adopt proper control or tune existing control system so that average ramp rate of 1% per minute in a 15-minute block is achieved in between 55% and 70%, resulting in a maximum machine ramp rate of 2% per minute. For loads between 70% and 100% an average scheduled ramp rate of 1.5% per minute in a 15-minute block may be adopted. Similarly, an average ramp rate of 0.5% per minute 15-minute block should be adopted for loads between 55% and 40% resulting in a maximum machine ramp rate of 1% per minute.

g) Online real time intelligent monitoring system for thermal stress, BTL prediction and load/demand forecasting solution may be implemented in all the generating units to facilitate operational decision making and avoiding blindly operating units under constrained condition to support grid with single/ multiple ramps up and ramp down cycles per unit per day. In absence of these online monitoring, the units face multiple BTL, overheating, weld joint failure, fin-cracks, flame failure and large deviation in major operating parameters etc. which can easily be avoidable under monitored operations.

h) OEMs have to declare all the unit's capabilities with respect to compliance with ramp rates and parameter deviation stipulated in contract specification. It shall be mandatory that OEM and the generating units shall declare commissioned unit's capability in compliance with CEA's specification/ standards/ guidelines and flexible operation regulations.

i) For fine grid balancing sufficient battery storage at certain specific locations may be installed.

j) It is also recommended to carryout the requisite modifications or changes in the respective regulatory framework to give effect to recommendation.

(2) The existing CERC compensation mechanism for operation at 55% MTL be expanded to include incremental O&M costs (up to max. 5%) arising from low-load operation, in addition to compensation for APC (Auxiliary Power Consumption), SHR (Station Heat Rate), and oil consumption degradation. This would enable comprehensive recovery of flexibility-related costs associated with increased wear, maintenance requirements, and reliability impacts on thermal generating units.

(3) SLDCs and RLDCs shall optimize dispatch of coal-fired generating units within their respective jurisdictions based on available operating margins between maximum and minimum generation levels. Final optimization shall be done by NLDC because available turndown margins at any region(s) and renewable generation waiting for integration into grid from any state(s) or region(s) are available with NLDC. Available turndown margins at thermal units should be utilized through schedule revisions to facilitate higher absorption of renewable energy across states and regions.

(4) DISCOMS shall maintain demand obligation so that generator gets Minimum Technical Load (MTL) Schedule during Solar hours, presently 55% and phase wise 40%. In case, DISCOMS fail to provide Minimum Technical Load (MTL) Schedule, a suitable penalty may be imposed.

(5) CEA has identified 151 coal-based generating units—totaling 34.5 GW of capacity and aged 35 years or older—for two-shift operations by 2030. Additionally, it has initiated a pilot study and data analysis at Tamil Nadu's 5x210 MW Tuticorin Thermal Power Station (TPS)

a) Recommended further study at the 210 MW Wanakbori TPS in Gujarat, and the 2x67.5 MW Southern TPS in Kolkata, both of which were already finalized in consultation with GSECL and CESC.

b) The committee recommends suitable retrofitting measures at 151 identified units, after a feasibility study for two-shift operation, which will enable them to operate for an additional 12–15 years and provide equivalent 27 GW storage in the grid.

c) The committee also recommends an exemption from FGD for these old power plants located in Category A and Category B, as they will operate to integrate green energy and stop generating during solar hours, thereby reducing their daily average SO2 and other emissions.

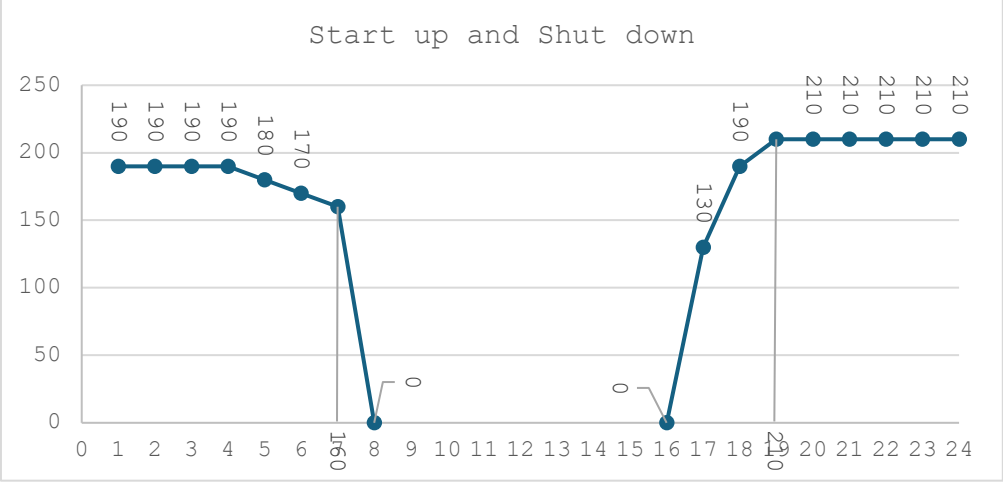
Annexure-I

Two-Shift Operation

1. Shutting down during Peak Solar Generation Period

The plant will be under shut down during solar peak generation period (9 am to 4 pm or 10 am to 5 pm) and units will generate in the evening peak with hot startup. The PLF of plants will be about 60%.

Two-shift operation is a costly mode of operation because of lower PLF and accelerated equipment life consumption due to daily start stop and increased forced outages. In the Indian market context, it will make economic sense for the older plants (with near-zero fixed costs/fully depreciated capital costs) to be retrofitted for a two-shifting mode of operation. As these plants would be on bar for a limited duration (16 hrs.), the overall emissions will be much lower, compared to the plants operating on lower loads for a longer duration.
The start-ups in daily two-shifting operations will mostly be hot start-ups, which are less damaging (equipment life consumption) than warm or cold start-ups. These plants are best placed, economically to deliver the peaking power (which can be opted as an Ancillary service product or suitable compensation mechanism to be installed).



2. Two-Shift Operating Experience

CESC Limited was operating the 2x67.5MW, BHEL make units of Southern Replacement TPS, commissioned in 1990 and 1991 respectively, in single/two shift mode for last 5 to 6 years, depending on merit order and system/network requirement. Running hours varies from 6 to 18 hours per day and type of start is hot or warm or cold depending on the number of hours of shutdown. No retrofitting (hardware/software) was done for single/two shift operation.

Another example of two-shift operation of 5X210 MW Tuticorin TPS and 4x210 MW Mettur TPS, Tamil Nadu where thermal power plants are operating during non-solar period and stop operation during solar period. Depending of requirement unit stop generation in between 7:20 am-11:45 am and again start generation in between 15:31pm – 19:14 pm.

The CEA and BHEL jointly visited the 5x210 MW Tuticorin TPS in Tamil Nadu to oversee the two-shift operation and collect operational data.

Data Analysis of 5X210 MW Tuticorin TPS

The CEA and BHEL jointly collected operational and design data from the 5x210 MW Tuticorin TPS, which the CEA then analyzed to determine the following;

(1) shutdown costs,
(2) start-up costs,
(3) retrofit costs, and
(4) increased O&M costs.

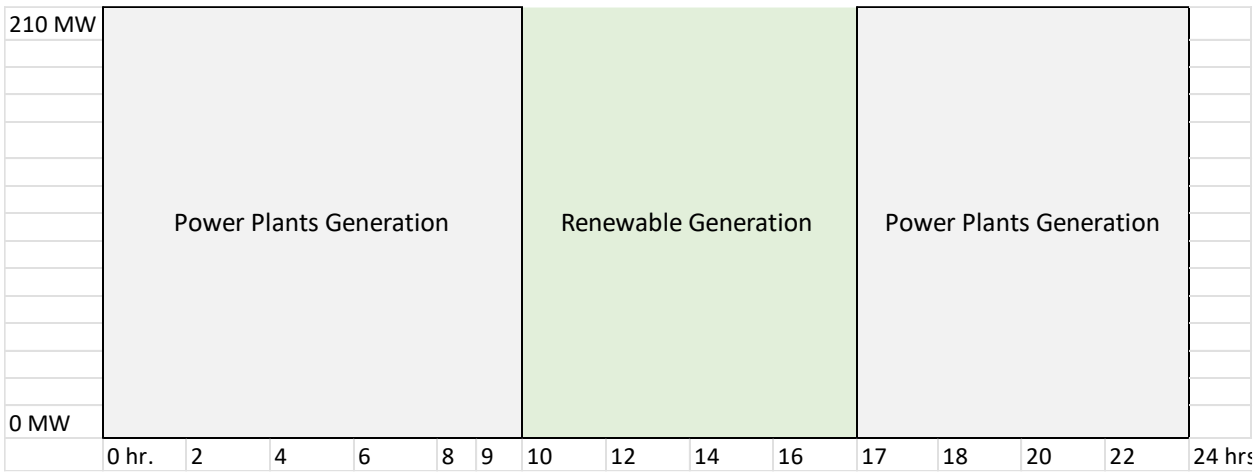
The following costs were identified from 5x210 MW Tuticorin data:

- Shutdown and startup costs (1 & 2): 29.42 paise/kWh,
- Increased O&M cost (4): 16.68 paise/kWh,
- The cost of retrofits (3) depends on the specific items required for regular two-shift operation and varies by unit. This cost can range from ₹120 crore to ₹250 crore. Consequently, the fixed component of the tariff will increase by 10.02 paise to 32.00 paise, assuming a 10-year payback period

The increased in tariff due to 2-shift operation also may vary as per below table:

Generation stop during Solar Period					
210 MW 12 yrs. Pay back	Capex (Crores)	Increase in FC (Paise/kWh)	Cost of Start/Stop	Increase in O&M cost	Total increase in tariff
			(Paise/kWh)	(Paise/kWh)	(Paise/kWh)
	120	16.35	29.21	16.68	62.24
	200	27.26	29.21	16.68	73.15
	250	34.06	29.21	16.68	79.95

3. Cost of integration of a unit of RE



i. Increased rate is applicable to the energy generated by 210 MW unit:
Daily generation = 210x1000x16 (kWh)
Daily compensation = 210X1000x16 (kWh)x 73.15 paise (capex. 200 cr.)
= Rs. 2457840.00

ii. Total RE to be integrated due to 2-shifting of a 210 MW unit
Daily renewable integration by 2-shifting = 210 MW X 8 hrs. X 1000 (kWh)
= 1680000 kWh

iii. The cost of a unit of RE integration by 2-shifting = (i)/(ii)

$$\text{Cost of integration of a unit of RE} = \frac{\text{Increased price} = \text{Rs.}2554272}{\text{Integrated RE} = 1680000 \text{ kWh}}$$

= Rs. 1.46

Note. Cost of integration will be increased to Rs. 1.60 with 250 cr. capex.

4. Potential capacity of renewable energy (RE) integration through two-shifting and its associated cost:

In the year, 2030 about 151 units of 34524 MW total capacity having age of 35 years & more in the country may operate at 2-shift mode.

Capacity for 2-shift operation: 34524 MW
78% of available capacity: 26928 MW
Flexible power available for integration: 24235 MW (considering 10% APC)

The capacity of 34524 MW shall provide 24.235 GW flexible power considering 78% availability factor and 10% auxiliary power consumption.
Total capex. for 151 units of 34.524 GW capacity = 151 X Rs. 200 Crores = Rupees 30200.00 Crores

Cost of a unit (kWh) renewable integration = Rs. 1.52 per kWh (RE)
Maximum 8-10 hrs. support would be available considering hot start of the unit

5. Cost of BSES for integration of same amount of renewable:

Capacity of BSES to provide flexible power of 24.235 GW= 26.928 GW (considering 10% loses)
Total capex for 26.928 GW BSES, 6 hrs. = Rs. 188496.00 Crores at the rate of Rupees Seven cr. per MW.
Discovered price of BESS, 4 hrs. single cycle with VGF = Rs. 3.61 per kWh of renewable
BESS with 6 hrs. is not available in the market, expected cost will more than Rs. 6.00/- per kWh renewable.

6. Units identified for pilot study:

CEA has already identified following power plants/ units for pilot study in consultation with respective generating utility:

a) 2x 210 MW Wankabori TPS, GECEL, Gujarat
b) 2X 67.5 MW Southern Generating Stations, CESC, West Bengal

7. Proposal for exemption from compliance of SO2 norms of old coal-based power plants located in Category-A and Category-B

As these power plants will not operate during the daily eight-hour solar window to accommodate green energy integration, their SPM, SO2, and NOx emissions will be non-existent during this period. This operational profile drastically reduces their daily average emission rates; therefore, an exemption from FGD installation is proposed for units operating under this two-shift mechanism.

Furthermore, a study conducted by IIT Delhi in ten cities across the country shows that SO_2 levels are well below the national standard of 80 µg/Nm³, typically ranging from 2.5 to 12.5 µg/Nm³. There is no evidence of SO_2 being a major public health concern under present conditions. Also, scientific studies confirm that sulfate particles from SO_2 have an insignificant contribution to suspended particulate matter (PM10/PM2.5). Other independent studies by NEERI Nagpur and NIAS also support the views of IIT Delhi.

The units proposed for 2-shift operation are listed in Annexure A

This includes 33 Category A units (5,867 MW capacity), 28 Category B units (7,880 MW capacity), and 90 Category C units (20,777 MW capacity). The proposal requests an exemption from SO2 norms for Category A and B units only, as Category C units are already exempt.

सत्यमेव जयते

भारत सरकार

Government of India

विद्युत मंत्रालय

Ministry of Power

केन्द्रीय विद्युत प्राधिकरण

Central Electricity Authority

तापीय परियोजना नवीनीकरण एवं आधुनिकीकरण प्रभाग

Thermal Project Renovation & Modernization Division

No. CEA/TPRM/2 SHIFT/2025/982-992 Dated 15.07.2025

विषय: Minutes of the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 02.07.2025 under the Chairmanship of PCE-II, CEA.

Reference is invited to the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 02.07.2025 under the Chairmanship of PCE-II, at 03:30 PM at Manthan Hall, 2nd Floor, CEA, Sewa Bhawan. The minutes of the meeting are enclosed herewith for further information and action.

This issues with the approval of Competent Authority.

Pravir Kumar

Director, TPRM

To:

1. Sh. Bikash Chandra Mallick , PCE-II , CEA
2. Sh. Surata Ram, CE, TPRM, CEA

3. Sh. Pravir Kumar, Director, TPRM, CEA
4. Sh. SK Pandey, CGM, DVC
5. Sh. Partha Nag, CGM, NTPC
6. Sh. S Bhattacharya, GM, BHEL
7. Sh. KV Singh, Sr. Manager, BHEL
8. Sh. Sanju Kumar Yadav, DGM, NTPC
9. Sh. Akhileshwar Maurya, DGM, NTPC
10. Sh. R. Sahoo, GM, WBPDCL
11. Sh. Manoj Kumar Agarwal, Executive Director, NRLDC, GRID INDIA
12. Sh. Nitin Yadav, DGM, GRID INDIA
13. Sh. AK Sinha, Technical Director, Intertek
14. Sh. Ripu Bhanjan Singh, USISPF

Minutes of the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 02.07.2025 under the Chairmanship of PCE-II, CEA.

Meeting Introduction:

At the outset, PCE-II welcomed all the members of the Committee. After a brief introduction of all the participants, the Chair, PCE-II, initiated the meeting by explaining background leading to formation of the committee. PCE-II later invited Grid India to update present grid scenario and implementation of CEA's flexible operation regulation,2023. Thereafter invited NTPC and other members for further discussion to elaborate on low load operation requirement for grid balancing and the damages due to low load.

Deliberations:

1. **GRID INDIA**: GRID-India confirmed that most Inter-State Generating Stations (ISGSs) and several State generating stations are operating at the 55% Technical Minimum Load (TML), while others are constrained by commercial—not technical—reasons. GRID-India emphasized the growing operational challenge from the duck curve caused by mid-day RE surplus and steep evening ramp (~60 GW). It was also stressed that state grid codes must align with CEA's "Flexible Operation of Coal-based Thermal Power Units Regulations, 2023," and financial mechanisms for SHR degradation, auxiliary power rise, and oil use must be embedded in tariff regulations (2024–29). Achieving India's target of 500 GW RE and 50% non-fossil energy by 2030 hinges on enhancing grid flexibility through flexible thermal operations, BESS, PSPs, and improved ramping capabilities. The Grid India representative highlighted the prevailing situation in the Indian power grid. **In the month of May-2025, frequency remained almost 20% of the time above the IEGC band** and persistently hovered above the band during solar hours for almost 4hrs from 12hrs window (06:00-18:00hrs). **On typical day of 25 May 2025 despite of reducing the thermal fleet of the country till 58% and backing down of IPP thermal generation till 55% & 10 GW of solar generation through TRAS Emergency down dispatch, still frequency touched to 50.48Hz, which is cause of concern for safe and secure grid operation**. Grid-India also informed that some of the units like Shree Cement (30% of DC), Rajpura (50% of DC), Talwandi Sabo (50% of DC), Adani-Raigarh (45% of DC), Mahan (45% of DC) are already going below 55%. Shree Cement plant in Northern Region is merchant plant and it is generating around 45MW (30%) during solar hours and 150MW (full capacity) during non-solar hours. Grid-India representative further stated that all India demand ramp requirement is 250- 300MW/minute and on special days it reached up to 500MW/minute, all India diurnal demand variation is ~75GW. It can be clearly observed that net demand evening ramp was around 60GW, which was met through thermal ramp of ~50GW and hydro ramp of ~10GW. Therefore all options for flexibilization need to be ensured such as, thermal flexibility in terms of 40% MTL, higher

ramp rate and two shift operation, as these are essential for supporting a rapidly evolving power system with high levels of variable renewable energy integration.

In reference to the present terms of this committee, GRID-INDIA apprised to the Committee that CERC vide order dated 29th March 2025 in suo-motu petition No. 2/SM/2025, has asked to conduct a pilot for 2 shift operation of thermal generating stations and NLDC to identify list of candidate thermal units (section 62, rail feed, preferably >500MW). Accordingly, NLDC has identified the candidate units for two shift operation of thermal generating station and communicated to NTPC vide its letter dated 22nd May 2025. NTPC was requested to confirm readiness of units identified and share the relevant information such as start-up costs for hot/warm start for each of the units. In response NTPC has requested to exempt from participating in the proposed pilot study on two-shift operation citing technical and operational constraints, reliability concerns, and the higher efficiency and environmental performance of NTPC units vide their letter dated 13th June 2025. Grid-India representative further highlighted that as per CERC order the pilot project for two shift operation is required to be carried out and incentive during this period is also specified by CERC. The pilot project will help in true assessment of wear & tear of m/cs, increased O&M expenses etc, so that a suitable compensation mechanism can be designed and implemented.

GRID-INDIA representative informed that Central Electricity Authority (CEA) has also envisaged requirement of two shift operations in future and accordingly provided provision of this requirement in technical specifications of Sub-critical Thermal Power Projects in September 2008 and also in Standard Technical Features for BTG System for Supercritical 660/ 800 MW thermal units," issued by CEA in July 2013.

Conducting a pilot for two-shift operation will enable the committee to assess wear and tear impacts, identify an appropriate compensation mechanism, and address other related concerns. It is, therefore, essential to initiate the pilot at the earliest, to facilitate implementation of two-shift operations on selected units within the next two years.

2. **NTPC**: Representative of NTPC informed members that all its units are running at 55% MTL but not going below it. More than 5000 MW is under USD. NTPC further submitted that it is witnessing increased cases of BTL because of thermal fatigue due to running at low load. NTPC submitted that for Grid balancing and minimising damages, multiple ramp up/down per day per unit should be avoided. He further informed that a similar committee has also been constituted by CERC for identifying units from ISGS utility under Section 62 of 500 MW Capacity for 2 shift operation pilot tests. NTPC further informed that NTPC as a group member of Sub-Group of Technical Experts constituted by CERC have presented NTPC Strategy in lowering the Minimum Turn down Level upto 55%.
3. **DVC**: Representative of DVC informed the committee that all its units were running at 55% MTL except Raghunathpur TPS (Chinese make). He further informed that Ball & Tube mills units too are running at 50% MTL on a regular basis after retrofits as per the recommendation of CEA Committee.

4. **WBPDCL**: Representative of WBPDCL stated that all units are capable to run up to 55%, but running at higher loads (mostly 70-%) due to schedule commitment and 70% is the MTL as specified by WBSERC. No damage is observed in units.
5. **MSPGCL**: Representative from MSPGCL submitted that MSPGCL is regularly running its units at 55% but facing much fluctuation in Schedule.
6. **PCE**-II informed generating utilities present in the meeting that increased BTL, flame failure etc may be due to not following standard operation procedure (SOP). CEA already circulated SOP for operating at 55% load in the year 2023 where CEA suggested mandatory training for Power Plant operators. Training details was also included in SOP which was prepared in association with NPTI. All the issues as mentioned by utilities shall be reduced once operators are provided training and they follow standard operation procedure (SOP).

7. **BHEL**: Representatives from BHEL submitted that even though damages are being observed while following flexible operation regime, such damages may not entirely be attributable to flexible operation. The damages observed have two components, first due to past operating history of the unit (operating regime, O&M practices etc.) and other due to flexible operation regime. The damages as observed are mainly because equipment/ components were close to threshold of failure before flexing started and with onset of flexing because of comparatively higher rate of life consumption early failure has occurred (as flexing is done with existing controls, without advanced solutions being implemented). Therefore, damage prior to flexing also needs to be accounted instead of attributing the failure to flexible operation alone.
   It was further highlighted that flexible operation regime will consume more life of the equipment than normal (base load) operating regime but the same can be controlled and mitigated if thermal units are made capable for flexible operation with implementation of advanced control solutions. The faster rate of deterioration being presently observed during flexible operation can be attributed to flexibilization of units without implementation of Flexibilisation solutions package. It was further suggested that a comprehensive study for ascertaining the damages, purely attributable to flexible operation needs to be carried out.

8. **INTERTEK**: Representative from Intertek informed that damage modelling has been carried out by Intertek in various units. According to which 70% of the damages was not due to flexible operation and a comprehensive study for the same needs to be carried out.
9. PCE-II asked all generating utilities if they feel increased BTL, flame failure etc. technically due to low load operation, identify units and submit data for damage modelling study.
10. DVC representative stated that they have not informed anywhere officially that operation at 55% load damages unit.

Decisions:

1. NTPC to submit technical data as per attached format so as to evaluate/quantify the damages due to flexible operation within 10 days from the date of meeting.

2. Intertek asked to share a data template with NTPC and committee members for better and requisite data capturing to quantify the damages due to flexible operation

List of Participants:

1. Sh. Bikash Chandra Mallick , PCE-II , CEA
2. Sh. Surata Ram, CE, TPRM, CEA
3. Sh. Pravir Kumar, Director, TPRM, CEA
4. Sh. SK Pandey, CGM, DVC
5. Sh. Partha Nag, CGM, NTPC
6. Sh. S Bhattacharya, GM, BHEL
7. Sh. KV Singh, Sr. Manager, BHEL
8. Sh. Sanju Kumar Yadav, DGM, NTPC
9. Sh. Akhileshwar Maurya, DGM, NTPC
10. Sh. R. Sahoo, GM, WBPDCL
11. Sh. Manoj Kumar Agrawal, Executive Director, NRLDC, GRID-INDIA
12. Sh. Nitin Yadav, DGM, GRID INDIA
13. Sh. AK Sinha, Technical Director, Intertek
14. Sh. Ripu Bhanjan Singh, USISPF

सत्यमेव जयते

भारत सरकार

Government of India

विद्युत मंत्रालय

Ministry of Power

केन्द्रीय विद्युत प्राधिकरण

Central Electricity Authority

तापीय परियोजना नवीनीकरण एवं आधुनिकीकरण प्रभाग

Thermal Project Renovation & Modernization Division

No. CEA/TPRM/2 SHIFT/2025/982-992 Dated: 08.09.2025

विषय: Minutes of the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 19.08.2025 under the Chairmanship of PCE-II, CEA.

Reference is invited to the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 19.08.2025 under the Chairmanship of PCE-II, at 03:30 PM at Manthan Hall, 2nd Floor, CEA, Sewa Bhawan. The minutes of the meeting are enclosed herewith for further information and action.

This issues with the approval of Competent Authority.

Pravir Kumar

Director, TPRM

To:

15. Sh. Surata Ram, CE, TPRM, CEA
16. Sh. Pravir Kumar, Director, TPRM, CEA

17. Sh. SK Pandey, CGM, DVC
18. Sh. S Bhattacharya, GM, BHEL
19. Sh. KV Singh, Sr. Manager, BHEL
20. Sh. Manas Kapoor, DGM, NTPC
21. Sh. Sanju Kumar Yadav, DGM, NTPC
22. Sh. Sumit Pandey, DGM, NTPC
23. Sh. Somara Lakara, NRLDC, GRID-INDIA
24. Sh. Nitin Yadav, DGM, GRID INDIA
25. Sh. AK Sinha, Technical Director, Intertek
26. Sh. Rajiv Patil, ED, MAHAGENCO
27. Sh. Bhupender Sharma, Sri Cements
28. Sh. Jaysinh Jadeja, Adani Power
29. Sh. Tanmay Vyas, Adani Power

Minutes of the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 19.08.2025 under the Chairmanship of PCE-II, CEA.

Meeting Introduction:

At the outset, **PCE-II** welcomed all the members of the Committee. Following a brief introduction of all participants, the Chair initiated the meeting by inquiring about the **status of data submission by NTPC**, as decided in the previous meeting on 02.07.2025 by 10 days.

Deliberations:

11. **NTPC**: The representative from NTPC informed the Committee that data collection is currently underway. They highlighted that the template shared by Committee was exhaustive and detailed, making the data compilation process time-consuming. NTPC requested Committee to share a simplified template comprising only critical data points. PCE-II advised NTPC to submit the data at the earliest.
12. **GRID INDIA**: The GRID INDIA representative stressed the urgency of NTPC's data submission, emphasizing that timely data is essential to assess actual damages due to low load operations. It was also noted that, to accommodate increased Renewable Energy (RE) integration, both 40% Minimum Technical Load (MTL) and two-shift operations need to run simultaneously.
13. **SRI CEMENT**: The representative from SRI CEMENT shared that their unit, operating with a CFBC boiler using normal coal, is regularly running at 30% without any retrofitting. PCE-II requested SRI CEMENT to submit relevant technical data for committee review.
14. **MAHAGENCO**: The representative submitted that all units are currently running regularly at 55%. He further submitted that running in two-shift operations are more damaging compared to continuous operation at 40% MTL.
15. **ADANI**: Representative of ADANI informed that all its units are running at 55%. No issue in running a unit at 55% MTL but facing impacts during cyclic loading. He further raised the issue of requirement of higher ramp rates (actual/real time) to meet the demand of ramp rates as per Flexible operation Regulations (Average).
16. **BHEL**: Representative of BHEL informed that units are operating in flexible operation mode without implementation of solutions. This is damaging the equipment life and will result in pre-mature failures. Implementing the solutions will mitigate the damage to equipment. Further, utilities are focusing only on meeting CEA regulations and not on addressing all the issues associated with Flexible Operation. New tenders are also focusing only on meeting CEA's regulation only. Hence, solutions to address Flexible Operation issues should be made part of standard specifications.
17. **Special Invitee INTERTEK:** Intertek submitted the observation that damages due to flexible operation arises mostly during startup/shutdown and ramping.
18. **PCE II** opined that damages due to operation at 55% are unlikely. Even damages can be reduced by few retrofits at 40% MTL. PCE II requested committee for conducting a feasibility

study regarding two-shift operation to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations of 210 MW size old units.

Decisions:

1. NTPC to submit technical data as per the updated format within 10 days from the date of the meeting, to facilitate evaluation and quantification of damages due to flexible operation.

2. CEA & Intertek to circulate an updated and simplified data template to NTPC and other committee members to ensure accurate data collection.

3. NTPC & DVC to identify one unit each of 210 MW unis with age greater than or equal to 40 years for Pilot test of 2 shift operation.

List of Participants:

30. Sh. Bikash Chandra Mallick , PCE-II , CEA
31. Sh. Surata Ram, CE, TPRM, CEA
32. Sh. Pravir Kumar, Director, TPRM, CEA
33. Sh. SK Pandey, CGM, DVC
34. Sh. S Bhattacharya, GM, BHEL
35. Sh. KV Singh, Sr. Manager, BHEL
36. Sh. Manas Kapoor, DGM, NTPC
37. Sh. Sanju Kumar Yadav, DGM, NTPC
38. Sh. Sumit Pandey, DGM, NTPC
39. Sh. Somara Lakara, NRLDC, GRID-INDIA
40. Sh. Nitin Yadav, DGM, GRID INDIA
41. Sh. AK Sinha, Technical Director, Intertek
42. Sh. Rajiv Patil, ED, MAHAGENCO
43. Sh. Bhupender Sharma, Sri Cements
44. Sh. Jaysinh Jadeja, Adani Power
45. Sh. Tanmay Vyas, Adani Power

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Thermal Project Renovation & Modernization Division

No. CEA/TPRM/2 SHIFT/2025/ Dated 30.10.2025

विषय: Minutes of the Meeting of the Committee to Examine Wear & Tear, O&M, and Plant Lifespan Implications of Two-Shift Operations in Thermal Power Plants Held on 15th October, 2025 (Wednesday) at 03:30 PM Manan Hall, 9th Floor, Sewa Bhawan, CEA, R.K. Puram, New Delhi.

Reference is invited to the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 15.10.2025 under the Chairmanship of PCE-II, at 03:30 PM at Manan Hall, 9th Floor, CEA, Sewa Bhawan. The minutes of the meeting are enclosed herewith for further information and action.

This issues with the approval of Competent Authority.

Rohit Yadav

Deputy Director, TPRM

To:

1. Shri B.C Mallick , PCE-II , CEA
2. Shri Surata Ram , CE , TPRM , CEA

3. Shri Rohit Yadav , DD , TPRM , CEA
4. Shri Vikalp Saini , AD ,TPRM, CEA
5. Shri S Bhattacharya , BHEL
6. Shri Nitin Yadav , NRLDC , Grid India
7. Shri Sunil Kumar Pandey , DVC
8. Shri Somara Lakra , NRLDC , Grid India
9. Shri Partha Nag , NTPC
10. Shri Shailendra Singh , NTPC
11. Shri Sanju Kumar Yadav , NTPC
12. Shri Anjan Kumar Sinha, Intertek

Minutes of the Meeting of the Committee to Examine Wear & Tear, O&M, and Plant Lifespan Implications of Two-Shift Operations in Thermal Power Plants
Held on 15th October, 2025 (Wednesday) at 03:30 PM
Manan Hall, 9th Floor, Sewa Bhawan, CEA, R.K. Puram, New Delhi

1. Introduction

The 3rd meeting of the Committee constituted to examine *Wear & Tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants* was held under the Chairmanship of **PCE-II, CEA** on **15th October, 2025** at **03:30 PM** in **Manan Hall, Sewa Bhawan, CEA, New Delhi**. The list of participants is attached as Annexure.

At the outset, **PCE-II** welcomed all the participants and explained the agenda of the meeting which was as under. He also informed the members that NTPC shared data on 07.10.2025, CEA and INTERTEK jointly analyzed the data and the preliminary report is ready for discussion.

1. Identification of one unit each of 210 MW capacity with age more than or equal to 40 years for pilot test/study of two-shift operation by NTPC and DVC, as decided in the previous meeting.
2. Analysis of data submitted by NTPC of 2 units viz., NTPC Farakka (210 MW) and NTPC Jhajjar (210 MW) (dated 08.10.2025).
3. Standard specifications and tender requirements for flexible operation (40% MTL) of coal-based generating units.

2. Deliberations

2.1 CEA and Intertek informed that after preliminary analysis of the data submitted by NTPC, it was observed that generation losses at Farakka TPS during the last 5 years to inter alia due to the recorded Reserve Shutdowns(7) (RSD), human error(6) , Boiler Tube Leakage (BTL)(12) , C&I issues(5), Electrical(8), other equipment & Operations issues (8) and five were planned outages(a total of 58 outages). The observed ramp rates remained conservative (within 0.5% in most operating blocks). Outages types includes cold (21) , warm (14) , Hot (23) .

For the last one year, the losses at NTPC Jhajjar are on account of outages due to Electrical (32 hours), TG (4.9 hours), BTL (52.3 hours) , PA duct Leakage (50.35 hours) and RSD (28.383 hours) .

The Farakka unit has not operated below 55% during normal load reduction (except for start-ups/ Shutdown). A conservative ramp rate of <0.5% has been maintained throughout, except in a few blocks. There has been no parametric variation, apart from the existing liabilities.

No significant damages is attributable to low load operation (during the existing flexible operation@55 % and conservative ramp rate of 0.5%. The unit has is part of NTPC's ageing fleet (39 years). And the life of equipment consumed due to ageing, can be reclaimed through R&M.

Representative form Intertek also pointed out that CFBC units and IPPs need to be studied for generation losses during low load operation..

2.2 NTPC stated that units across all States need to achieve 55% MTL compliance so that the operational burden of flexibilisation is not concentrated solely on NTPC stations. NTPC agreed to submit additional operational data of units experiencing frequent ramp-up and ramp-down cycles to facilitate further analysis of wear and tear patterns associated with frequent low-load and frequent high-ramping conditions.

2.3 DVC informed that no unit of 210 MW capacity with age greater than or equal to 40 years is presently available for pilot testing of two-shift operation, as the older units are currently undergoing ESP upgradation activities.

2.4 Grid India informed that NTPC has been given the operational choice to either run selected units at 40% load or operate them under Reserve Shut Down (RSD) conditions. It was highlighted by BHEL and Intertek that operation at 40% load is expected to be significantly less damaging than repeated RSD **cycles**. Grid India further suggested that analysis may also be extended to Independent Power Producers (IPPs), such as Shree Cement, which have been operating units at around 30% load regularly.

2.5 Mahagenco was requested by PCE-II to nominate one suitable unit for pilot testing of two-shift operation. Mahagenco informed that the matter will be deliberated internally, and a suitable unit will be identified and communicated shortly. It was also conveyed that frequent backing-down cycles in some Mahagenco units have led to operational challenges and maintenance issues. Mahagenco will also provide data of backing down in the given format, if required.

2.6 BHEL expressed that the damages and stresses associated with flexible operation can be significantly mitigated through appropriate retrofitting and control modifications to enable stable 40% MTL operation.

2.7 Intertek, Grid India and BHEL expressed that there should be a guideline for standard specifications and tender requirements for flexible operation (40% MTL) of coal-based generating units for the new builds/incoming capacity.

3. Action Points

1. **NTPC** to submit detailed operational data of units having frequent ramp-up and ramp-down cycles for further analysis to assess wear and tear under low-load and high-ramp conditions.
2. **CEA and Intertek** to prepare and submit a **comprehensive analysis report** on wear and tear patterns based on NTPC's data, including observations on equipment degradation and maintenance trends.
3. **Mahagenco** to **identify and nominate one unit** suitable for pilot testing of two-shift operation and inform CEA accordingly and will also provide the data of backing down in the given format, if required, for analysis of the data for impact of frequent ramping and low load operation on plant life.
4. Data may be obtained from Shree Cement which is operating at below 40% MTL for analysis.

4. Conclusion

The Chair emphasized that the assessment of two-shift operation must be supported by sufficient operational data to quantify the wear and tear impacts accurately.

The meeting concluded with a vote of thanks to the Chair.

ANNEXURE

List of Participants:

1. Shri B.C Mallick , PCE-II , CEA
2. Shri Surata Ram , CE , TPRM , CEA
3. Shri Rohit Yadav , DD , TPRM , CEA
4. Shri Vikalp Saini , AD ,TPRM, CEA
5. Shri S Bhattacharya , BHEL
6. Shri Nitin Yadav , NRLDC , Grid India
7. Shri Sunil Kumar Pandey , DVC
8. Shri Somara Lakra , NRLDC , Grid India
9. Shri Partha Nag , NTPC
10. Shri Shailendra Singh , NTPC
11. Shri Sanju Kumar Yadav , NTPC
12. Shri Anjan Kumar Sinha , Intertek

Annexure-A

NTPC Concerns along with Committee Observations

1. Concerns on Two-Shift Operation & Deep Flexing

NTPC expressed serious concerns over two-shift operations and 40% load flexing, citing their adverse impact on unit health.
Operating units below 55% load is highly detrimental for the health and life of thermal units. NTPC is already experiencing high boiler tube leakages, frequent flame failures, and a significant increase in generator and turbine failures over the past three years. Repeated ramp-ups and ramp-downs are accelerating wear and reducing the lifespan of thermal units. NTPC is not in a position to operate their units under two-shift operations. Impact of two shift operation on life and forced outages will not be visible immediately or during test duration; they may only get manifested after a certain period of time (say 3–4 years). Hence, the purpose of getting data/impact through two shift operation trials will not be trustworthy.

Committee Reply:

NTPC expressed serious concerns over 40% load flexing which is not on the basis of any scientific study/analysis. Even a 39 years old generating units of NTPC where maximum damages occurred as per NTPC, found mostly due to other reasons. The Committee observes that the extent of damages and BTL as revealed from NTPC's data appears to be exaggerated. The available data indicates that units have largely operated at 55% load and never operated at 40% load; therefore, attribution of damages to low-load operation is not substantiated. Damages due to start-up, shutdown, and forced cooling are well established to be more severe than steady low-load operation. Further, the contention that impacts are not immediately visible is noted; however, this reinforces the need for long-term structured studies rather than avoidance of pilot implementation.

In this regard it may be noted that the concept of pilot phase was introduced in the CEA's Regulation,2023 before starting 1st phase where 10 units were identified for longer duration operation after carrying out appropriate retrofit measures. This will help to systematically assess the real-world impact, operational challenges etc. However, NTPC have not carried out any retrofits or modifications in last three years on the identified three units (Mauda Unit-1, Simhadri Unit-3 and Dadri Unit-6) under pilot phase for trial operation.

Continuation of frequent start-stop regimes effectively leads to two-shift type operation in practice, particularly for low-merit units. The committee was in favour of feasibility study for 2-shift operation for which requested to identified a 210/200 MW unit. If 2-shifting is not feasible, committee will never recommend for 2-shift operation. It is very unfortunate that NTPC is opposing feasibility study for 2-shift operation, instead expressed their concerns without any study.

2. Boiler & Combustion Related Concerns

Indian coal quality (30–50% ash, low volatile matter, low GCV) is inherently unsuitable for stable firing below 55% load.
At 40% load, flame intensities weaken drastically, increasing susceptibility to flame failure. Multi-mine coal sourcing without blending infrastructure amplifies combustion instability.

Low loads reduce flue gas velocity, causing duct ash accumulation and structural risks. Frequent temperature cycling between 40% and 100% accelerates boiler fatigue and increases tube leak incidents.
Coal mills experience high vibration and unstable performance at low loads, leading to outages. Reduced flue gas temperature increases cold-end corrosion in APH and ESP.

Committee Reply:

NTPC's statement is hypothetical as they have not either retrofitted nor operated any unit below 55% load. Further, CEA (Flexible Operation of Coal Based Thermal Power Generating Units) Regulations, 2023 were notified following successful pilot studies conducted across the country and based on continuous five years analysis of various related data, stakeholder's consultations etc. As per CEA, Regulation generating units shall be suitably retrofitted before operating at 40% MTL (Minimum technical Load) to avoid all issues as mentioned by NTPC.
The Committee noted that while coal quality and combustion characteristics do influence low-load stability, these challenges are operational and design-specific and can be mitigated through appropriate measures such as coal blending, optimized mill operation, and control system improvements. Evidence from operational practices indicates that such issues are manageable with proper O&M procedures and retrofits. Further, combustion-related issues, including flame failures, have been observed even at higher loads, indicating that they are not solely attributable to low-load operation. Therefore, attribution of these issues exclusively to flexible operation is not justified without detailed plant-specific analysis.

3. Operational Constraints

Increased risk of high vibration & stalling in PA fans at low loads. Critical steam parameters fluctuate sharply, increasing protection limit violations. Ramp rate performance deteriorates due to reduced control margins. At ≤55% load, AGC, FGMO, and PFR support cannot be reliably provided. Supercritical units enter wet mode at ~40% load, causing severe operational challenges.

Committee Reply:

The Committee observes that the stated operational constraints are largely dependent on operational practices and control strategies. It is evident that improper operation at low loads without suitable procedural modifications can lead to instability; however, demonstrated cases indicate that with appropriate configuration (such as optimized fan and mill operation), stable operation is achievable. The performance of ramp rates and grid support functions requires further validation under realistic operating conditions, and no conclusive evidence has been provided to establish inability at 55% load. These aspects need to be validated through structured testing and data analysis rather than being treated as inherent limitations. Most of the super-critical units in the country enter wet mode at ~35% load and only few unit's benson point is at 30% or 40% load. The Units with benson point 40% load could be discussed on case to case basis.

4. Turbine-Related Concerns

Increased risk of LP blade flutter leading to fatigue and reduced blade life. Main steam temperature fluctuations cause casing distortion, rotor vibration, and centerline shifts. HP/IP casings develop ovality (~3 mm) and cracks due to thermal cycling. Metallurgical degradation reduces casing life by ~40%. Exfoliation and increased spray flows cause blade deposition and efficiency loss. Control valves suffer fatigue, erosion, and steam cutting damage at low loads.

Committee Reply:

The Committee acknowledges that flexible operation introduces additional thermal cycling; however, the magnitude of impact due to 55% load operation as indicated requires validation. The assertion of significant life reduction (e.g., ~40%) is not supported by detailed fatigue or creep studies and appears to be based on assumptions as NTPC has never operated any unit at 40% load. It is well established that start-up and shutdown cycles contribute more significantly to turbine damage compared to steady part-load operation. Accordingly, proper assessment using validated methodologies is necessary before drawing conclusions on life reduction.

5. Concerns on OEM (BHEL) Proposal

Allowable excursion ranges proposed by BHEL are too wide (e.g., ±15°C vs ±3°C). Ramp rate demonstration methodology does not align with NLDC methodology. Requirement of no mill addition/withdrawal during ramps is impractical. Requirement of consistent coal quality is unrealistic. Response from BHEL pending despite repeated follow-ups. BHEL requirements assume a highly controlled environment, not feasible in real operation.

Committee Reply:

The Committee notes the concerns regarding the proposed conditions. Committee opines that more advanced state-of-the art AI driven adaptive APC control could reduce the temperature excursion much lesser than ±15°C instead of using only APC. However, these aspects require technical validation through demonstration and detailed engagement with OEMs. The requirement of controlled conditions for initial validation is a standard engineering practice and does not preclude subsequent adaptation for real-time operations. Differences in ramp rate assessment methodology and operational constraints need to be harmonized through joint studies involving utilities, NLDC, and OEMs. However, it is informed that NLDC consider 1% ramp rate per minute only and to achieve 1% ramp, generating unit requires 2% ramp capability. As per CEA's Regulation a generating unit shall be capable to achieve 2% ramp rate per minute in between 55% to 70% and vice versa. It is also emphasized that no comprehensive study has yet been undertaken on retrofitted units to evaluate the effectiveness of flexibilization measures, and such studies are essential before drawing definitive conclusions.

……..

Annexure-B

NTPC's dissent on draft Report of the Committee

Report Section	CEA Draft Report	NTPC Comments
2.1 para 1	GRID-India informed that most inter-state Generating Stations (ISGSs) and several state generating stations have technically achieved 55% Technical Minimum Load (TML).	Instead of using word "several", use precise capacity of Genco's operating with TML of 55% in terms of % capacity. Action plan for implementation of the same need to be incorporated.
2.1 para 2	The all-India diurnal demand variation is of the order of 75 GW, with national ramping requirements typically in the range of 250–300 MW per minute, rising to 500 MW per minute on certain days. Achieving India's target of 500 GW of renewable energy capacity and 50% non-fossil energy by 2030 is contingent upon significantly enhancing grid flexibility through a combination of flexible thermal operation (40% MTL), two-shift operation, battery energy storage systems (BESS), and pumped storage projects (PSPs).	The all-India diurnal demand variation is of the order of 75 GW, with national ramping requirements typically in the range of 250–300 MW per minute, rising to 500 MW per minute on certain days. Achieving India's target of 500 GW of renewable energy capacity and 50% non-fossil energy by 2030 is contingent upon significantly enhancing grid flexibility through a combination of battery energy storage systems (BESS), Pumped storage projects (PSPs) and flexible operation up to 55% by all thermal stations of the country. In this regard, Energy storage planning under CEA NGAP 2026–27 to 2035–36 has been carried out considering a 55% technical minimum for thermal stations, and the same needs to be implemented.
2.1 para 3	GRID-India highlighted the prevailing grid security challenges during May 2025, wherein system frequency remained above the Indian Electricity Grid Code (IEGC) operating band for nearly 20% of the time, with sustained high-frequency conditions during solar hours for almost four hours with in the 06:00-18:00 hrs window. On 25 May 2025, despite backing down the national thermal fleet to approximately 58% and curtailing nearly 10 GW of solar generation through TRAS emergency down dispatch, system	GRID-India highlighted the prevailing grid security challenges during May 2025, wherein system frequency remained above the Indian Electricity Grid Code (IEGC) operating band for nearly 20% of the time, with sustained high-frequency conditions during solar hours for almost four hours within the 06:00-18:00 hrs window. On 25 May 2025, despite many of the units being under USD and backing down by the national thermal fleet to approximately 58% including curtailment of nearly 10 GW of solar generation through TRAS emergency down dispatch system, frequency still rose to 50.48 Hz, posing a serious concern for safe and secure grid operation. Due to non-participation by many of the intra-

Report Section	CEA Report	NTPC Comments
	frequency still rose to 50.48 Hz, posing a serious concern for safe and secure grid operation. The extent of RE curtailment month wise as intimated by Grid India is given below.	state generating stations, maintaining grid frequency became even bigger challenge for Grid- India. Thermal power continues to remain the backbone of the Indian power system, mximum demand met during solar hours was 270.7 GW on 21st May at 15:47 hrs, with thermal contributing 171.8 GW (63.4%). During non-solar hours, the maximum demand met was 253.2 GW at 22:53 hrs on 22nd May, with thermal contribution of 181.7 GW (72%). This underscores the critical role of thermal power in the system and the need to take all necessary measures to safeguard thermal assets
2.1 para 4	GRID-India further informed that due to the inability of several thermal stations-particularly at the intra-State level-to operate at 55% MTL, maximum renewable energy curtailment more than 23 GW, as indicated in the above Table had to be undertaken during high solar generation periods, underscoring the urgent need for deeper thermal flexibility. It was also pointed out that several generating units are already operating below 55% MTL, including Shree Cement (≈30% of DC), Rajpura (≈50%), Talwandi Sabo (≈50%), Adani Raigarh (≈45%), and Mahan (≈45%). Shree Cement's merchant plant in the Northern Region was specifically cited, which operates at around 45 MW (30%) during solar hours and ramps up to full capacity (≈150 MW) during non-solar hours, demonstrating the technical feasibility of low-load operation.	GRID-India further informed that due to the inability of several thermal stations-particularly at the intra-State level-to operate at 55% MTL, maximum renewable energy curtailment more than 23 GW, as indicated in the above Table had to be undertaken during high solar generation periods, **underscoring the urgent need for specifying uniform MTL of 55% for all thermal stations of the country and bringing intra-state and Regional IPP stations under the comprehensive ambit of SCUC, SCED & Ancillary Services for optimum and cost effective dispatch at the national level.** It was also pointed out that very few generating units (Shree Cement, Rajpura, Talwandi Sabo, Adani Raigarh and Mahan) are already operating below 55% MTL. **However, as per the Committee (MoP, CEA, NTPC) observations during the visit to Shree Cement plant, in addition to its CFBC technology, the plant exhibits very slow ramping capability and high start-up/shutdown time, rendering it unsuitable for meeting grid flexibility requirements.**
2.3	International scenario on flexibility	In this context, a detailed study is required to be conducted w.r.t. the quality of coal (GCV, ash content, volatile matter and several other factors) being used in these stations to support the deep flexible operation. Before proceeding with deeper flexibility, **the safety aspects of part-load operation,** especially considering

		Indian coal characteristics such as

Report Section	CEA Report	NTPC Comments
		low volatile matter, high ash content, and moisture need to be carefully evaluated and reviewed.
2.4	Central Electricity Authority (CEA) initiated countrywide 40% low load operation pilot study/tests in association with international partners (IGEF, DEA, JCOAL) and OEMs (BHEL, GE, SIEMENS) since 2018 which demonstrated the 40% low load operation capability of coal-based generators. Considering high ash content in Indian coal, and after 5 years successful multiple pilot study/test, CEA notified flexible operation regulation in 2023 regarding 40% minimum technical load (MTL) of coal-fired power plants to be achieved phase-wise by 2030.	Central Electricity Authority (CEA) initiated countrywide 40% low load operation pilot study/tests in association with international partners (IGEF, DEA, JCOAL) and OEMs (BHEL, GE, SIEMENS) since 2018 which demonstrated the 40% low load operation capability of coal-based generators **under highly controlled environment for very short period of time. However, the potential damage to regular deep flexing up to 40% MTL is still to be assessed.** After 5 years of multiple pilot study/test, CEA notified flexible operation regulation in 2023 regarding 40% minimum technical load (MTL) of coal-fired power plants to be achieved phase-wise by 2030.
2.5	However, NTPC, vide its letter dated 13.06.2025, sought exemption from participation in the proposed pilot study, citing technical and operational constraints, reliability concerns, and the comparatively higher efficiency and environmental performance of its units. GRID-India highlighted that as per the CERC order, the pilot project for two-shift operation is mandatory, and that incentives during the pilot period have also been specified by CERC. The pilot study is essential for a realistic assessment of wear and tear, increased O&M expenditure, and operational impacts, which would enable formulation of a robust and evidence-based compensation mechanism.	However, NTPC, vide its letter dated 13.06.2025 **(Annexure-1)**, sought exemption from participation in the proposed pilot study, citing technical and operational constraints, reliability concerns, and the comparatively higher efficiency and environmental performance of its units. **NTPC reiterated that impact of two shift operation on life and forced outages will not be visible immediately or during test duration, rather they get manifested in around 2-3 years' time. Hence, the purpose of getting data/impact through two shift operation trials will not be trustworthy. It is pertinent to note that the EPRI Technical Report "1001507" indicates that the Equivalent Forced Outage Rate (EFOR) for cycling units is significantly higher than that of base-load units in nearly all cases. The report also highlights an initial time lag of about seven years between the peak number of starts and the peak in EFOR. As the plant ages, this lag reduces to approximately three years and continues to decrease further with advancing plant age.**

2.6	**Operational/ technical data of NTPC's power plants for analysis for damages** NTPC generating units are presently operating at 55% Minimum Technical Load (MTL); however, NTPC has not operated its units below this level. NTPC submitted that it is	**NTPC's view on flexible operations** **A) Boiler & Combustion Challenges** Indian coal quality (30–50% ash, low volatile matter, and low GCV) is inherently unsuitable for stable firing below 55% load. At 40%, flame intensities weaken drastically, increasing

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	witnessing an increased incidence of Boiler Tube Leakages (BTL), which, according to NTPC, are attributable to thermal fatigue arising from low-load and flexible operating conditions. NTPC emphasized that, from the perspective of grid balancing and minimization of equipment damage, multiple ramp-up and ramp-down cycles per unit per day should be avoided, as such operating patterns significantly aggravate thermal stresses and fatigue damage. NTPC also highlighted that total 692 Boiler Tube Leakages (BTL) were reported fleetwide from FY 2021–22 to September 2025, averaging 6.68 BTL per unit. 10 instances of flame failure and 11 of 15 BTL events at Farakka were attributed to fatigue failure, overheating, and weld joint failure. The committee members requested NTPC on 1st meeting held on 02.07.2025 to submit operational/ technical data in a prescribed format of any unit which was operating flexibly up to 55% MTL leading to damage. After several reminders and persuasion, NTPC submitted operational/ technical data on 07.10.2025 to the Committee for analysis (after three months). Data pertaining to Farakka Unit–2 (210 MW) of age 39 years old and Jhajjar Unit–3 (210 MW) of age 13 years, covering outage categorization, ramping behaviour, and operational events during flexible operation. NTPC submitted that the data reflects increased mechanical and thermal stresses experienced by plant components due to flexible operation at 55% MTL.	susceptibility to flame failure from even minor disturbances. Multi mine coal sourcing without blending infrastructure further amplifies combustion instability due to rapid variations in coal properties. Low loads also reduce flue gas velocity, causing duct ash accumulation, posing risks of structural damage. The repeated high cyclic load results in heavy stress particularly on thick-walled component of boiler and turbine which deals with high temperature and pressure. Frequent temperature cycling between 40% and 100% load accelerates boiler fatigue, leading to higher tube leak incidents. It includes all fatigue failures such as Tube Fin Attachment failures, Tube to scallop weld joint failures, Attachment Failures, Header Stub Joint failures, and DMW weld joint failure etc. Coal mills experience high vibration and unstable performance at low feed rates, leading to frequent outages Reduced flue gas temperatures increase cold end corrosion in APH and ESP sections. **B) Operational Constraints** There is increased risk of high vibration & stalling in Primary air (PA) fans at low loads, Critical steam parameters (SH/RH temperatures, HRH pressure, economizer outlet temperature) fluctuate sharply, increasing the likelihood of protection limit violations. Ramp rate performance deteriorates due to reduced control margins. At 55% and below AGC, FGMO, and PFR support cannot be reliably provided. Supercritical units experience even more severe challenge since at 40%, they enter into wet mode from dry mode. **C) Turbine Constraints** Low load operation increases risk of LP blade flutter, which accelerates fatigue and reduces blade life. Main steam temperature fluctuations cause casing distortion, centre-line shifts, and increased rotor vibrations. HP/IP casings develop ovality (up to 3 mm) and cracks from thermal cycling, and metallurgical degradation reduces casing life by ~40%. Exfoliation and increased spray flows accelerate solid particle deposition on blades, reducing turbine efficiency. Control valves face severe

		fatigue, erosion, and steam cutting damage at low lifts.

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		NTPC has also prepared a detailed report on the effects of flexible operation on various thermal units of NTPC in the last 5-6 years which is attached as **Annexure-2.** **D) Progress on assessment of the effects of flexible operation in NTPC units** As per the MOM dated 17.11.2025, MOP advised NTPC to explore the feasibility of implementing BHEL Advance process control System to address flexible operation requirements for subcritical Units. Accordingly, NTPC vide mail dated 24.11.2025 requested BHEL to submit a comprehensive technical and commercial offer mentioning the deliverables. However, the offer submitted by BHEL has several limitations and impractical technical provisions some of which are as follows: • BHEL has asked for very wide allowable excursion range of operating parameters such as steam temperature standard deviation of +/- 15 ºC against the generally allowable range of +/- 3 ºC and Furnace pressure Standard deviation of +/- 30 mm WC against the generally allowable variation range of +/- 12 mm WC. • BHEL's offer of demonstrating ramp rates of 3%, 2% and 1% per min does not align with ramp rate assessment methodology of NTPC which is based on average change of generation in between two-time blocks. • BHEL has asked for sufficient stabilization time during each ramp trials stating that no addition and withdrawal of mills to be attempted during ramps which is not practical in real time operation • BHEL has also asked for consistency in coal quality to be ensured by NTPC during load ramp/low load trials although maintaining consistency in coal quality is not in NTPC hands as the coal is supplied from various sources. With the emerging BESS and PSP landscape and sharp decline in cost of BESS in the recent past, storage solutions are expected to play a critical role in

		balancing the grid, avoiding RE curtailment and mitigating the need for deep flexible operation or two shift operation

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		of thermal stations. Further, as highlighted by EPRI **(Annexure-3),** damage due to one cycle of deep flexible operation of a thermal unit (ramp down to 40% and then again ramp up to full load) is equivalent to damage due to ~ 0.5-0.8 times of a hot start-up. This translates to reduction in life of a thermal unit to 14-20 years. It was also deliberated in meeting that operating a unit under 2-shift operation is much more damaging than deep flexible operation. **E) Ramping** NTPC generating units are presently operating at 55% Minimum Technical Load (MTL). All NTPC thermal units are also complying to the ramp rate of 1% of ex-bus capacity corresponding to MCR on bar per minute as mandated in IEGC 2023. With respect to ramping of thermal units, NTPC submitted that to achieve an average ramp of 1% per minute over 15 minutes time block, the unit effectively ramps at 2–3% per minute during the active ramping window of approx. 5 minutes, compensating for boiler response delay time at the start and stabilization time at the end.
2.6 Para 4	After several reminders and persuasion, NTPC submitted operational/ technical data on 07.10.2025 to the Committee for analysis (after three months).	The committee members requested NTPC on 1st meeting held on 02.07.2025 to submit operational/ technical data in a prescribed format of any unit which was operating flexibly up to 55% MTL leading to damage. However, in the subsequent meeting held on 19.08.2025, NTPC sought change in the prescribed format citing it to be too exhaustive and detailed, requesting for a simpler format comprising only of critical data points. Accordingly, after receipt of the revised format, NTPC submitted operational/ technical data on 07.10.2025 to the Committee for analysis.
2.6	OEM perspective on damages:	The OEM may clarify the rationale for not attributing the increase in boiler tube leakages to flexible operation. OEM should also clearly outline the proposed retrofitting measures, along with a firm assurance regarding the expected residual life or life extension of the equipment. In addition, the OEM (BHEL) should provide detailed observations on generator and boiler failures in NTPC units, consistent with the findings shared with NTPC on issues arising from flexible operation. NTPC is ready to share the observations provided by OEM(BHEL) in this regard. The OEM should also

		specify the retrofitting solutions planned for operation with low volatile matter (VM), wet Indian coal.

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2.7	Data analysis of NTPC units	It is observed that data provided by NTPC is analysed at constant load of 55% but the analysis under varying ramp conditions, which is more representative of actual flexible operations, is yet to be undertaken. In the letter dated 15.11.2025, NTPC also provided data pertaining to increase in Boiler Tube Leakages attributable to increased flexible operation of several thermal stations like Farakka, Mouda, Talcher Kaniha, NPGC etc., This section of report needs to be reviewed with NTPC. The report provided by NTPC with regard to flexible operation impact needs to be considered. In addition to this NTPC has submitted a detailed report of the flexible operation impacts on 24th Feb 2026 and these are to be included in the final report.
2.7.3	NTPC's analysis correlates all failures to flexible operation, ignoring other dominant causes such as: o Frequent start-ups and shutdowns, o Sub-optimal O&M practices o Improper preservation or forced cooling, o Coal quality deviation, and o Human and procedural errors. Evidence from global and national studies shows that thermal stress and fatigue primarily accumulate during start-up, shutdown, and tripping events — not during steady low-load operation.	No justification has been presented for attributing failures to sub optimal O&M practices, improper preservation or forced cooling, human errors etc. It appears that these conclusions are not based on the data submitted.

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2.7.7	Start-up Severity and Operator Practices: The USAID–Intertek "Cost of Cycling" study (NTPC Ramagundam, 2017) shows that one poorly executed start-up can cause up to 16 thermal cycles in a single component (e.g., reheat desuperheater). Proper operator training and start-up procedures can drastically reduce this damage	Data referred to arrive at this conclusion may kindly be shared with NTPC for further analysis. NTPC has not submitted 2017 data to CEA.
2.7.8	Both units did not operate below 55% MTL during normal conditions. The analysis indicated no significant damage attributable to low-load operation at 55% MTL.	In the 3rd committee meeting dated 15.10.2025 and also vide letters dated 15.11.2025 & 21.11.2025, NTPC stated that the data provided by NTPC is analysed at constant load of 55% **but the analysis under varying ramp conditions, which is more representative of actual flexible operations, is yet to be undertaken.** In the letter dated 15.11.2025, NTPC also provided data pertaining to increase in Boiler Tube Leakages attributable to increased flexible operation of several thermal stations like Farakka, Mouda, Talcher Kaniha, NPGC etc. The letters dated 15.11.2025 and 21.11.2025 are attached as Annexure-5 and Annexure-6 respectively.
2.7.9	Approximately 70% of the observed issues were not due to flexible operation, but related to ageing, poor coal quality, or operational disturbances. It was therefore concluded that while flexibility introduces some additional thermal stress, the existing conservative operations have not shown measurable degradation directly attributable to low-load running.	No justification has been provided to arrive at the conclusion that 70% of the observed issues were not due to flexible operation. Instead of concluding that flexibility introduces some additional thermal stress, accurate thermal stress analysis may be done under varying load conditions from 55% to 100% and vice versa.

2.7.10	For accurate assessment, NTPC was requested to provide mode-wise data under: ➢ steady full-load operation,	NTPC has provided the requisite data on 15.11.2025 (Annexure-5) and no communication received from CEA after providing the same. NTPC also submitted the report on impact of flexible operation (Annexure-2).

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	➢ continuous low-load operation, ➢ ramping operation, ➢ start-ups (post-tripping and post-outage), ➢ forced cooling, and ➢ poor coal quality scenarios. NTPC was further requested on 15.10.2025 to share operational/technical data of any other units where damages occurred due to flexible operation. However, till the finalization of report (14.01.2026) they have not shared any data to the Committee.	**If any further data is required, NTPC is ready to provide the same.**
2.8	Despite four Committee meetings, multiple written requests, and communications from CEA, Grid India, and CERC, NTPC has not nominated any unit for pilot two-shift operation trials. Grid India, in consultation with CERC, had identified ten NTPC units suitable for such trials to establish a scientific compensation methodology, but NTPC has not confirmed any for study. Similarly, DVC and Maha Genco also have not identified/ offered any such unit for feasibility studies.	Despite four Committee meetings, multiple written requests, and communications from CEA, Grid India, and CERC, **none of the entities have nominated any unit for pilot two-shift operation trials.**
2.9.1	The data shared by NTPC so far is limited to two units and cannot be extrapolated to the entire NTPC fleet. Averaging fleet-wide failures is not a scientifically valid approach, as units differ in age, operating history, maintenance standards, coal quality etc. Units beyond their design life naturally show higher failure rates (as represented by the "bathtub curve"). Based on available data and empirical	No justification has been provided to arrive at the conclusion that damages are due to improper start-up/shutdown procedures, Human & procedural errors, poor combustion management etc. and not attributable to flexible operation. The operational and technical data presently available is limited in scope, and therefore insufficient to draw definitive conclusions regarding the long-term impacts of deep flexibilization and two-shift operation on coal-based thermal units.

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	evidence, it is confirmed that **no significant damage has been observed that can be attributed directly to low-load operation (at 55% MTL and conservative ramp rates).** The principal sources of accelerated wear and tear remain improper start-up/shutdown procedures, Human & **procedural errors**, poor combustion management etc. Therefore, the focus should be on measures implementation for achieving 40% Minimum Technical Load (MTL) in consultation with OEM/main plant (BTG) manufacturer /BTG designer, improving operational discipline, and training of plant operators to manage cycling efficiently, rather than associating damage solely with flexible operations	Reduction in MTL beyond 55% may be considered after comprehensive study on the detrimental effects on the life of equipment and life guarantee assurance by the OEM.
2.9.2	The damages and stresses associated with flexible operation (below 55%) can be significantly mitigated through appropriate retrofitting and control modifications. The generating utilities shall conduct detailed study/tests for finding the most optimal solutions to improve the flexibility of plants as the measures required are unit specific and shall depend on the level of flexibilization. It is also advised to refer CEA's report "Flexibilization of coal-based power plants"- a roadmap for achieving 40% Technical Minimum Load (MTL) published in 2023**.**	While certain retrofit measures and control system modifications can improve flexibility to an extent, however such retrofits alone do not eliminate fundamental design limitations of pressure parts, auxiliaries, and balance-of-plant systems.
2.9.3	**CERC's direction for conducting 2-shift operation pilot study**:	In response to the communication from NLDC regarding participation in a two-shift operation pilot study on 22.05.2025, NTPC conveyed its concerns vide letter dated 13.06.2025 (Annexure 1) and sought

		exemption from participation in the proposed pilot

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	On the direction of CERC, NLDC identified candidate units and communicated the same to NTPC vide letter dated 22.05.2025, requesting confirmation of unit readiness for 2-shift operation and submission of start-up cost data for hot and warm starts. However, NTPC, vide its letter dated 13.06.2025, sought exemption from participation in the proposed pilot study, citing technical and operational constraints, reliability concerns, and the comparatively higher efficiency and environmental performance of its units.	study, citing technical and operational constraints, reliability concerns, and the comparatively higher efficiency and environmental performance of its units.
2.9.3	The Committee's request for identification of a unit: The committee also requested NTPC number of times to identify an old unit of capacity 210 MW for 2-shift operation pilot study/test. However, they are reluctant, and no response has been received since 1st meeting held on 02.07.2025 till finalization of the report.	NTPC opines that such units are already operating under significant ageing-related constraints. Subjecting them to aggressive cycling could lead to disproportionate damage, safety risks, and unplanned outages, without generating transferable or scalable insights.
2.9.4	Pilot study for 2-shift operation In view of the present grid scenario and curtailment of large quantity renewable generation it is essential to carry out the feasibility study for 2-shift operation at smaller size old units preferably less or equal to 210 MW of age more than 35 years. The pilot study includes examination/tests of unit for viability of two shift operations (to understand technical & operational constraints if any and reliability of 2-shifting),	In view of the present grid scenario, it is essential to specify uniform MTL of 55% for all thermal stations of the country and bring intra-state and Regional IPP stations under the comprehensive ambit of SCUC, SCED & Ancillary Services for optimum and cost-effective dispatch at the national level. Further, with the emerging BESS and PSP landscape and sharp decline in cost of BESS in the recent past, storage solutions are expected to play a critical role in balancing the grid, avoiding RE curtailment and mitigating the need for deep flexible operation or two shift operation of thermal stations. In this regard, it is essential to evaluate the need for deep flexing and two-shift operation of coal-based thermal stations.

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	then potential damage (life consumption) to the unit, retrofits/capex. requirements, tariff impact, etc. This continued non-availability of pilot units has hindered progress on examination of feasibility, empirical validation of damage mechanisms, delayed formulation of a regulatory compensation framework etc. for two-shift operation.	

Recommendations:

1. Uniform MTL of 55% needs to be specified for all thermal stations of the country and all intra-state and Regional IPP stations need to be brought under the comprehensive ambit of SCUC, SCED & Ancillary Services for optimum and cost-effective dispatch at the national level.
2. Several NTPC units are experiencing cyclic V or W type ramping during the day, increasing the no. of ramps to more than 6 in a day. For example on 19th May 2026, 63 out of 130 units of NTPC experienced more than six ramps a day. Such type of blind cyclic scheduling without real time monitoring to thermal stations results in mechanical/thermal stresses on the boiler and turbine equipment's and the same needs to be avoided.
3. OEM should clearly outline the proposed retrofitting measures especially for low volatile matter (VM) and wet Indian coal, along with a firm assurance regarding the expected residual life or life extension of the equipment. In addition, the OEM should provide detailed observations on generator and boiler failures in NTPC units, consistent with the findings shared with NTPC on issues arising from flexible operation.
4. With the emerging BESS and PSP landscape and sharp decline in cost of BESS in the recent past, storage solutions are expected to play a critical role in balancing the grid, avoiding RE curtailment and mitigating the need for deep flexible operation or two shift operation of thermal stations. In this regard, the need for deep flexing and two-shift operation of coal-based thermal stations may be reviewed.
5. Impact of deep flexing and two shift operation on life and forced outages will not be visible immediately or during test duration, rather they get manifested in around 2-3 years' time. Hence, the purpose of getting data/impact through two shift operation trials will not be trustworthy.
6. Any software/tools/real time data analytics that are available in the market may be

suggested as part of the report to be installed in thermal power plants to study the wear and tear in thermal power plants

Part-load compensation is presently limited to **accounting for Heat rate and APC degradation only** during operation at lower loading levels. However, NTPC generating units are presently being operated continuously under highly flexible regimes receiving multiple ramps in a day (sometimes V-shaped W-shaped, and M-shaped scheduling patterns also) in order to meet evolving grid requirements. Participation of NTPC stations in various grid support mechanisms such as SCUC, SCED and Ancillary services further intensifies this flexible operation. Such regular cyclic operations have significant long-term implications on machine life, efficiency, reliability, and maintenance requirements, which are presently not recognized or compensated under the existing regulatory framework. Furthermore, the number of tripping instances also increased due to flame failure at part load.

In addition, a substantial number of NTPC units are being subjected to Unit Shutdowns (USD) due to below MTL scheduling by beneficiaries, followed by revival within short durations of one to two days. Such frequent shutdown and start-ups impose severe thermal and mechanical stresses on critical equipment and adversely impact unit reliability and life expectancy. During FY 2025–26, a total of 130 units were placed under USD. Further, during April 2026 alone in FY 2026–27, 11 units were taken under USD.

It is also pertinent to note that even during shutdown periods, substantial auxiliary power is continuously consumed for operating essential equipment and systems required to maintain unit readiness for revival, resulting in additional financial burden on the generating station. However, no specific compensation mechanism presently exists for recovery of these costs. Further, revival of units after USD necessitates significant consumption of fuel oil, which is also not adequately compensated under the prevailing regulatory provisions.

भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
तापीय परियोजना नवीनीकरण एवं आधुनिकीकरण प्रभाग
Thermal Project Renovation & Modernization Division

No. 2/3/TPRM/TSO/ Date: 17.06.2025

Subject: Constitution of Committee to Examine Wear & Tear, O&M, and Plant Lifespan Implications of Two-Shift Operations in Thermal Power Plants - reg

Reference is invited to the Minutes of Meeting held under the chairmanship of Secretary (Power) on **27.05.2025**, regarding the review of issues related to grid management and the updated projection of summer power demand (copy enclosed). In the said meeting, it was directed that **CEA and Grid India in consultation with thermal power generators**, should thoroughly examine the **potential damage to the country's thermal plant fleet including wear and tear, operations & maintenance (O&M) requirements, and plant lifespan before considering implementation of two-shift operations**.

In this regard, a **Committee comprising the following members** has been constituted to examine the implications of two-shift operations on thermal power plants:

1. **Shri B.C. Mallick**, Principal Chief Engineer-II – *Chairman*
2. **Chief Engineer/Director, TPRM Division** – *Convener & Member*
3. **Representative from** NTPC, DVC, MAHAGENCO, and WBPDCL – *Members*
4. **Representative from** Grid-India – *Member*
5. **Representative from OEM (BHEL) –** *Member*
6. **Shri Shubhranshu Patnaik**, Partner, Deloitte India – *Member*

The Committee may co-opt other members/ domain experts, if required.

The services of the following technical experts may be availed by the committee, as and when required.

1. **Shri Anjan Kumar Sinha**, Technical Director, Intertek Inc., USA – *Member*
2. **Shri Ripu Bhanjan Singh ,** Senior Director ,USISPF- *Member*

17/6/25

(Pravir Kumar)
Director, TPRM

To:

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8. Shri Anjan Kumar Sinha, Technical Director, Intertek Inc., USA
9. Shri Ripu Bhanajn Singh , Senior Director , US-India Strategic Partnership Forum

Copy To:

1. Chairperson , CEA
2. Member (Thermal) , CEA
3. PCE- II , CEA